

MONTHLY WEATHER REVIEW.

Editor: Prof. CLEVELAND ABBE.

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INTRODUCTION.

The REVIEW for July, 1896, is based on 2,746 reports from stations occupied by regular and voluntary observers, classified as follows: 149 from Weather Bureau stations; 33 from U. S. Army post surgeons; 2,421 from voluntary observers; 33 from Canadian stations; 1 from Hawaii; 96 received through the Southern Pacific Railway Company; 14 from U. S. Life-Saving stations. International simultaneous observations are received from a few stations and used together with trustworthy newspaper extracts and special reports.

The WEATHER REVIEW is prepared under the general editorial supervision of Prof. Cleveland Abbe. Unless otherwise specifically noted, the text is written by the Editor, but the statistical tables are furnished by Mr. A. J. Henry, Chief of the Division of Records and Meteorological Data. Special acknowledgment is made of the hearty cooperation of Prof. R. F. Stupart, Director of the Meteorological Service of the Dominion of Canada, Mr. Curtis J. Lyons, Meteorologist to the Government Survey, Honolulu, and of Dr. Mariano Bárcena, Director of the Central Meteorological Observatory of Mexico.

CLIMATOLOGY OF THE MONTH.

GENERAL CHARACTERISTICS.

The pressure has been high off the south Atlantic Coast, and also off the north Pacific Coast, and the interior low pressure has been about normal. Consequently the distribution of winds has also been normal and the mean temperatures for the month have shown no large abnormality. There was a general excess of temperature on the Pacific Coast and a general deficiency in the interior of the continent. Although several stations on the north Pacific and Plateau regions reported the highest mean temperature on record, yet the greatest excess was but 4.2° . An unusual number of stations reported heavy local rains and consequent disastrous floods over very restricted areas; the greatest departures from normal precipitation at regular stations of the Weather Bureau were the excesses in Kansas, Missouri, Arkansas, Illinois, Mississippi, Ohio, Kentucky, West Virginia, Louisiana, and Alabama. An injurious drought was reported from limited portions of Arkansas, Louisiana, Mississippi, and Texas, also, in Washington and Oregon.

ATMOSPHERIC PRESSURE.

[In inches and hundredths.]

The distribution of mean atmospheric pressure reduced to sea level, as shown by mercurial barometers, not reduced to standard gravity, and as determined from observations taken daily at 8 a. m. and 8 p. m. (seventy-fifth meridian time), is shown by isobars on Chart IV. That portion of the reduction to standard gravity that depends on latitude is shown by the numbers printed on the right-hand border.

The mean pressures during the current month were highest on the coast of the South Atlantic States and Washington. They were lowest in Arizona and southern California, and low in the Gulf of St. Lawrence.

The highest were: Charleston, 30.16; Jacksonville, Jupi-

ter, and Tampa, 30.15; Wilmington and Savannah, 30.14. The mean for Bermuda was 30.27.

The lowest were: Yuma, 29.78; Prince Albert, 29.82; Fresno, Phoenix, and Red Bluff, 29.84; Grindstone Island, 29.85; Sacramento, 29.86; Father Point, 29.87; Medicine Hat, 29.89.

As compared with the normal for July, the mean pressure was in excess throughout the country east of the Rocky Mountains; in the South Atlantic Coast States it was greatest. It was slightly deficient over the Pacific States. The greatest excesses were: Charleston, 0.12; Wilmington, 0.11; Kittyhawk, Hatteras, Augusta, Jacksonville, Edmonton, and Minnedosa, 0.10. The greatest deficits were: Portland, Oreg., Walla Walla, and Eureka, 0.04; Sacramento and Fresno, 0.03.

As compared with the preceding month of June, the pressures, reduced to sea level show a rise everywhere, except a slight fall on the Pacific Coast. The greatest rises were: Wilmington, Charleston, Jacksonville, Tampa, and Bermuda, 0.11; Hatteras, Savannah, Jupiter, Atlanta, Montgomery, Mobile, New Orleans, Galveston, Palestine, Abilene, Santa Fe, and Edmonton, 0.10. The greatest falls were: Portland, Oreg., Walla Walla, and Roseburg, 0.08; Eureka, 0.07.

AREAS OF HIGH AND LOW PRESSURE.

By Prof. H. A. HAZEN.

The general conditions of the month of July have been as follows: A persistent low pressure to the north of Montana from which 10 of the 11 storms of the month have taken their origin. Four of the high areas of the month have also originated to the north of Montana, but these have been of very slight magnitude. There were 11 storms and 7 high areas of sufficient definiteness to be traced, and their trajectories, with barometer reading twice each day, will be found on Charts I and II, respectively. Some of the more prominent facts relating to the place of origin, velocity of apparent motion,

and duration of path will be found in the accompanying table.

Movements of centers of areas of high and low pressure.

Number.	First observed.			Last observed.			Path.		Average velocities.	
	Date.	Lat. N.	Long. W.	Date.	Lat. N.	Long. W.	Length.	Duration.	Daily.	Hourly.
High areas.										
I.....	3, a.m.	48	108	6, a.m.	40	94	1,320	3.0	440	18.3
II.....	5, a.m.	53	109	8, p.m.	47	84	1,610	3.5	460	19.2
III.....	18, a.m.	48	129	18, p.m.	44	63	2,990	5.5	590	25.0
IV.....	20, p.m.	54	116	21, a.m.	48	98	910	2.5	362	15.1
V.....	23, a.m.	51	116	26, a.m.	37	74	2,330	3.0	778	32.4
VI.....	26, p.m.	47	104	28, p.m.	42	87	940	2.0	471	19.6
VII.....	29, a.m.	54	110	31, p.m.	44	81	1,560	2.5	624	26.0
Sums.....							11,660	22.0	3,734	.....
Mean of 7 paths.....									533	22.2
Mean of 22.0 days.....									530	22.1
Low areas.										
I.....	1, a.m.	52	108	5, a.m.	43	72	2,340	4.0	590	23.3
II.....	6, a.m.	52	117	8, p.m.	51	98	870	2.5	347	10.9
III.....	6, p.m.	29	93	10, a.m.	47	86	1,650	3.5	471	19.7
IV.....	8, p.m.	50	110	11, a.m.	54	102	610	2.5	244	10.2
V.....	13, p.m.	50	106	16, p.m.	48	61	2,160	3.0	720	30.0
VI.....	15, p.m.	52	115	19, p.m.	41	90	1,870	4.0	468	19.5
VII.....	18, p.m.	52	112	21, p.m.	49	63	2,480	3.0	827	34.5
VIII.....	20, a.m.	48	111	23, p.m.	48	58	2,690	3.5	770	32.1
IX.....	20, p.m.	46	117	25, p.m.	44	64	3,390	5.0	667	27.8
X.....	24, a.m.	54	107	27, p.m.	42	83	1,860	3.5	531	22.1
XI.....	27, p.m.	50	116	31, p.m.	46	59	2,790	4.0	697	29.0
Sums.....							22,630	38.5	6,302	.....
Mean of 11 paths.....									573	23.6
Mean of 38.5 days.....									529	22.0

LOCAL STORMS.

By A. J. HENRY, Chief of Division of Records and Meteorological Data.

There were about the usual number of local storms, torrential rains, and damaging hailstorms during the month. No remarkable tornadoes occurred, but possibly some of the local violent winds were really incipient tornadoes. Minor tornadoes were reported in North Carolina and Virginia on the 8th, and in South Carolina on the 15th. Very severe local storms were experienced in Michigan, Iowa, Ohio, and Pennsylvania on the 26th and 27th, and damaging hailstorms occurred in South Dakota, Iowa, and Indiana on the 26-27th. The loss to crops in South Dakota on this occasion probably exceeded \$100,000. Careful estimates of loss in Iowa in the counties of Woodbury, Cherokee, Plymouth, Ida, Sac, Buena Vista, and Calhoun place the damage to crops at \$200,000.

The record by dates follows:

4th.—A severe squall wind passed over Cedar Point about 3 miles northeast of Sandusky, Ohio, capsizing a number of yachts and pleasure boats. One person was drowned.

6th.—Bucklin, Ford County, Kans., was visited by a severe wind, rain, and hail storm, reported as moving toward the southwest. The width of the storm was about 5 miles; its length was probably not over 15 miles. The damage was confined to windmills, small buildings, fruit crops, and poultry.

7th.—A severe windstorm began on the west Florida coast on the morning of the 7th, increasing in force as the day advanced. The maximum velocity of the wind at Pensacola (72 miles per hour from the southeast) was reached at 11.45 a. m. Much damage was done in that city. About 35 houses were unroofed, and there was a general destruction of signs, awnings, telegraph and telephone wires, smokestacks, windmills, etc. The greatest destruction, however, occurred in the harbor, and on the water front. Nine fishing smacks were sunk; one brig dragged her anchor and was washed ashore; two barks were badly damaged and a number of smaller craft wrecked and sunk. The property loss has been estimated as high as \$400,000 in Pensacola alone, but that

statement seems excessive. Probably \$100,000 would be nearer the true figures. Strong winds were also reported at Eufaula, Ala., and Winston, N. C.

8th.—An incipient tornado formed in Halifax County, N. C., at 9.30 a. m., and moved northeastward in a path about 60 or 70 feet wide. At Spring Hill several houses and a number of outbuildings were blown down: one person was killed. Length of track uncertain, but probably not over 10 miles. The property loss was about \$1,000. Later in the day what appears to have been a series of minor tornadoes was observed in Dinwiddie and Prince George counties, Va. Reports as to the general direction of the storms are somewhat conflicting. The observer at Reams Station reports a storm moving northwest. Two independent reports from Templeton almost due east of the first-named point give the direction as "a little east of north" and "north," respectively. The observer at Disputanta reports the storm as moving northwest. Funnel clouds were also seen moving in a northeasterly direction toward Williamsburg; 5 persons were injured; property loss about \$1,200. The path of the main storm varied in width from 50 to 200 yards; its length was probably 20 miles, but there was no destruction over a portion of its course.

14th.—A heavy wind and rain storm visited southern Michigan. The damage done at Grand Haven was estimated at \$20,000.

15th.—A minor tornado, or what might be called an overgrown whirlwind, was observed about 2 miles north of Hartsville, S. C. One dwelling was blown down, and one person injured. The whirlwind's path was about 300 feet wide and 3 or 4 miles long; loss insignificant. Cincinnati, Ohio, was visited by a severe thunderstorm. The damage was confined principally to telephone wires, trees, awnings, truck and flower gardens, and suburban roads. A series of severe thunderstorms swept over the portions of West Virginia bordering on the Ohio River, from Parkersburg to the upper end of the Pan Handle, and extending back into the interior as far as Lewis and Harrison counties. Houses, bridges, and sawmills were swept away on the headwaters of the upper Little Kanawha, and on other streams emptying into the Ohio. The rainfall was very heavy throughout Ohio, east Tennessee, and western Pennsylvania. At Pittsburg the rain was very heavy. The street car lines, with but one exception, were wrecked, and considerable damage was done to houses and their contents by flooding. The early newspaper accounts of the damage done in Pittsburg were much exaggerated.

19th.—Damaging hailstorms were reported a few miles north of Aberdeen, S. Dak.

23d.—General rains fell over Illinois on this date. In a few cases the winds were unusually strong, and considerable damage was done to the crops, fences, and standing timber.

25th.—An incipient tornado or waterspout was observed in the suburbs of New Orleans. The damage done was insignificant, and the tornado disappeared in the direction of Lake Pontchartrain.

26th.—An unusually destructive hailstorm passed over a strip of country about 60 miles in length, and from 5 to 10 miles in width, in the southeastern part of South Dakota. The storm originated in the eastern part of Bon Homme County, traveled southeast through the counties of Yankton, Clay, and Union, across the Big Sioux River near Akron, and was last reported in the northwestern part of Plymouth County, Iowa.

Another destructive hailstorm passed through Jerauld County, S. Dak., destroying every vestige of crops in its path, in a strip about 20 miles long and 4 miles wide. The damage in the last-named county was estimated at \$25,000; the damage in Yankton County was estimated at \$100,000; no reports have been received as regards the damage in Clay and Union

counties. Following is a description of the storm in Yankton County, by Mr. Henry G. B. Swinhoe, station agent, Weather Bureau, Yankton, S. Dak.:

I have the honor to report that a hailstorm of great severity occurred in this locality yesterday (July 26), doing an immense amount of damage, estimated in this county alone at \$100,000. The path of the storm included the best farming section of the county, from Lesterville on the west to Gayville on the east, and varying in width from 5 to 10 miles. This portion is practically laid waste, a few spots being less seriously damaged. The crops were beaten into the ground, the leaves and branches were stripped from the trees, and numbers of hogs and chickens were killed. Probably a small portion of the oats, which were in shock, may be saved; but the wheat, standing in the field, is completely destroyed where the hail occurred, and the thousands of acres of fine corn are now reduced to leafless stumps. The crops were the best that have been raised here for the last five or six years, and the loss to many of the farmers will be irreparable. Many specimens of hailstones and broken corn stalks were brought in by farmers this morning. Some of the stones measured 1½ inches in diameter sixteen hours after they had fallen; they were of very rugged appearance. Farmers from the worst part of the storm report a sea of ice and mud many miles in extent, the hail in the ravines being 2 feet in depth. The storm appeared to travel from east to west several miles north of Yankton during the forenoon of Sunday, the atmosphere being very sultry, and a light breeze from the southeast. The storm appeared to remain stationary in the northwest till between 2 and 3 p. m., when it commenced to approach, and at the same time divided into two parts, one going south into Nebraska, and the other going east, at about 4 miles north of Yankton. This station, lying between the two main parts of the storm, received 0.74 of an inch of rain, and a maximum wind velocity of 38 miles per hour. No hail fell here, and no damage was done. The temperature was highest (86.9°) about one hour before the storm; during the storm the temperature fell to 64.5°. The color of the clouds in the distance was an inky black, changing on a near approach to a dark green, while the roar of the hail sounded at this station like distant thunder. I am told that some of the hailstones weighed 1 pound, twenty hours after the storm. They were composed of a number of very hard lumps of ice about one-half inch in diameter each, held together by soft ice, forming a mass sometimes 3 inches in diameter. Large holes were made through shingle roofs, and the overhanging eaves of buildings were chipped off.

In Iowa, Nebraska, and South Dakota crops were also damaged by wind, rain, and hail. The storm was unusually severe in Marshall Co., Iowa. At St. Anthony, Albion, and Green Mountain a number of buildings were wrecked. One person was severely injured at Albion. The property loss will probably aggregate \$10,000. The greatest damage by hail in Iowa was in Ida, Sac, and Cherokee counties. Severe local storms occurred in southern Michigan, the destruction being greatest in the vicinity of Homer, Three Rivers, Battle Creek, and Northville; other points also suffered.

27th.—The 26th and 27th were days of unusual storm frequency. Iowa, Wisconsin, and Michigan were visited by severe local storms on the 26th, and Indiana, Illinois, Ohio, Pennsylvania, Maryland, New Jersey, and New York on the 27th. These storms seemed to develop simultaneously over large areas, although a progressive movement from west to east was noticed in some cases. The storms in Ohio and western Pennsylvania were unusually severe. At Columbus, Ohio, buildings were unroofed and otherwise damaged by the wind. At Pittsburg, Pa., 2 persons were killed and 7 injured. The damages by wind and flood were very great. The storms did but little damage in central Pennsylvania, but throughout the eastern portion of the State and in New Jersey they were quite severe. An incipient tornado cloud was seen at Gibson City, Ill.; the funnel did not reach to the earth.

28th.—Hail of great size fell in and about Montpelier, Ind., damaging crops and killing live stock.

29th.—A minor tornado occurred at Gloucester, Ohio, at 7.55 p. m., central time. One person was killed and 10 were injured. Property loss about \$4,000. The storm moved northeast then southeast in a path 150 yards wide and 1½ miles long. A severe wind and thunderstorm, in which the wind was said to have a whirling motion counter clockwise, occurred at Huntington, Ind. Three persons were injured. The storm's path was very irregular; it was reported as mov-

ing first from west to east, then southeast and finally northeast; its path was from one-quarter to one-half mile wide and 15 miles long. Property loss (buildings only) probably not over \$3,000. A destructive hailstorm originated in the central part of Edmunds Co., S. Dak., near Ipswich; passing southeast, destroying the crops and breaking the glass in a great number of windows in its course to the eastern part of Spink County. The path of greatest destruction was about 5 miles wide and 20 miles long.

Casualties during the month by lightning, 87.

TEMPERATURE OF THE AIR.

[In degrees Fahrenheit.]

The mean temperature is given for each station in Table II, for voluntary observers. Both the mean temperatures and the departures from the normal are given in Table I for the regular stations of the Weather Bureau.

The *monthly mean temperatures* published in Table I, for the regular stations of the Weather Bureau, are the simple means of all the daily maxima and minima; for voluntary stations a variety of methods of computation is necessarily allowed, as shown by the notes appended to Table II.

The *regular diurnal period* in temperature is shown by the hourly means given in Table V for 29 stations selected out of 82 that maintain continuous thermograph records.

The *distribution of the observed monthly mean temperature* of the air over the United States and Canada is shown by the dotted isotherms on Chart IV; the lines are drawn over the Rocky Mountain Plateau Region, although the temperatures have not been reduced to sea level, and the isotherms, therefore, relate to the average surface of the country occupied by our observers; such isotherms are controlled largely by the local topography, and should be drawn and studied in connection with a contour map.

The *highest mean temperatures* were: Yuma, 91.3; Phoenix, 88.0; Shreveport and Fort Smith, 84.6; Little Rock, 84.2; Galveston, 83.6; San Antonio, 83.4; Palestine, 83.4; New Orleans, 82.8; Savannah and Port Eads, 82.6; Charleston and Memphis, 82.4; Key West, 82.3. The lowest mean temperatures were: Tatoosh Island, 57.0; Fort Canby, 61.2; Eastport, 62.2. Among the Canadian stations the highest were: Spences Bridge, 74.6; Medicine Hat, 70.2; Toronto, 68.2; Port Stanley, 68.0; Kingston, 67.4. The lowest were: Father Point, 58.0; Banff and Esquimaux, 58.6.

As compared with the normal for July the mean temperature for the current month was in excess in portions of the lower Lake Region and south Atlantic Coast, as also over New England, the northern Plateau Region and Missouri Valley. It was deficient especially in the northern and southern Slope and Pacific Coast Region. The greatest excesses were: Roseburg, 4.8; Calgary and Spokane, 4.2; Walla Walla, 3.9; Sacramento, 3.3; Chatham, 3.2; Baker City, 3.1; Swift Current and Fresno, 2.8; Medicine Hat, 2.7. The greatest deficits were: El Paso, 4.2; Williston, 2.6; Omaha, 2.5; Santa Fe, 2.4; Jupiter, 2.3; Huron and Sioux City, 2.2.

Considered by districts the mean temperatures for the current month show departures from the normal as given in Table I. The greatest positive departures were: Northern Plateau, 3.3; north Pacific, 2.3; middle Pacific, 2.2. The greatest negative departures were: Florida Peninsula, 2.0; southern Plateau, 2.1.

The *years of highest and lowest mean temperatures* for July are shown in Table I of the REVIEW for July, 1894. The mean temperature for the current month was the highest on record at: Fresno, 85.5; Fort Smith, 84.6; Little Rock, 84.2; Walla Walla, 79.1; Sacramento, 76.5; Winnemucca, 73.4; Spokane, 73.2; Roseburg, 71.3; Idaho Falls, 69.6; Carson City, 69.3; Astoria, 64.1; Fort Canby, 61.2; Port Angeles, 58.9. The mean temperature for the current month

was not the lowest on record at any regular station of the Weather Bureau.

The *maximum and minimum temperatures* of the current month are given in Table I. The highest maxima were: 110, Yuma (frequently); 109, Phoenix and Redbluff (9th); 106, Walla Walla (15th); 104, Sacramento (9th); 103, Fort Smith (28th), Little Rock (31st), Bismarck (11th). The lowest maxima were: 67, Point Reyes Light (frequently); 70, Tatoosh Island (21st), Port Angeles (19th), Eureka (31st); 72, San Francisco (9th). The highest minima were: 73, Galveston (11th); 72, Port Eads and Key West (7th), Corpus Christi (frequently); 70, Charleston (9th), Savannah and Jacksonville (7th), Pensacola (8th), New Orleans (1st). The lowest minima were: 38, Williston (22); 40, Havre (24th); 41, Pysht (3d); 43, East Clallam (1st) and Bismarck (22d).

The *years of highest maximum and lowest minimum temperatures* are given in the last four columns of Table I of the current REVIEW. During the present month the maximum temperatures were the highest on record at: Bismarck and Little Rock, 103; Meridian, 102; Memphis, 101; Pensacola, 99. The minimum temperatures were the lowest on record at: Williston, 38; Jupiter, 68.

The *greatest daily range of temperature and data for computing the extreme and mean monthly ranges* are given for each of the regular Weather Bureau stations in Table I. The largest values of the greatest daily ranges were: San Luis Obispo, 45; Idaho Falls and Winnemucca, 44; Havre, 43; Carson City, 42; Miles City, 41; Fresno, 40. The smallest values were: Woods Hole and Galveston, 13; Corpus Christi and Jupiter, 14; Key West and Hatteras, 15; Port Eads and Block Island, 16; Nantucket, 17; San Diego, 18; Charleston, Pensacola, Eureka, Fort Canby, and Point Reyes Light, 19; Tampa, Mobile, San Francisco, and Tatoosh Island, 20.

Among the *extreme monthly ranges* the largest were: Denver, 66; Bismarck, 60; Havre, 58; Walla Walla, Carson City, and Fresno, 55; San Luis Obispo, Winnemucca, Williston, and Miles City, 54. The smallest values were: Corpus Christi, 18; Port Eads, 10; Point Reyes Light, 21; Key West, San Francisco, Tatoosh Island, and Woods Hole, 22.

The *accumulated monthly departures from normal temperatures from January 1 to the end of the current month* are given in the second column of the following table, and the average departures are given in the third column for comparison with the departures of current conditions of vegetation from the normal condition.

Districts.	Accumulated departures.		Districts.	Accumulated departures.	
	Total.	Average.		Total.	Average.
Middle Atlantic.....	+ 2.6	+ 0.4	New England.....	- 0.6	- 0.1
South Atlantic.....	+ 8.1	+ 1.2	Florida Peninsula.....	-11.7	- 1.7
West Gulf.....	+ 8.6	+ 1.2	East Gulf.....	- 0.9	- 0.1
Ohio Valley and Tenn.....	+ 9.0	+ 1.3			
Lower Lake.....	+ 9.5	+ 1.4			
Upper Lake.....	+20.5	+ 2.9			
North Dakota.....	+ 8.1	+ 1.2			
Upper Mississippi.....	+19.9	+ 2.8			
Missouri Valley.....	+19.3	+ 2.8			
Northern Slope.....	+ 9.8	+ 1.4			
Middle Slope.....	+21.9	+ 3.1			
Abilene (southern Slope).....	+21.4	+ 3.1			
Southern Plateau.....	+ 5.6	+ 0.8			
Middle Plateau.....	+ 3.0	+ 0.4			
Northern Plateau.....	+15.9	+ 2.3			
North Pacific.....	+ 1.4	+ 0.2			
Middle Pacific.....	+ 1.4	+ 0.2			
South Pacific.....	+ 6.0	+ 0.9			

MOISTURE.

The *quantity of moisture* in the atmosphere at any time may be expressed by the weight of the vapor coexisting with the air contained in a cubic foot of space, or by the

tension or pressure of the vapor, or by the temperature of the dew-point. The mean dew-points for each station of the Weather Bureau, as deduced from observations made at 8 a. m. and 8 p. m., daily, are given in Table I.

The *rate of evaporation* from a special surface of water on muslin at any moment determines the temperature of the wet-bulb thermometer, but a properly constructed evaporimeter may be made to give the *quantity* of water evaporated from a similar surface during any interval of time. Such an evaporimeter, therefore, would sum up or integrate the effects of those influences that determine the temperature as given by the wet bulb; from this quantity the *average humidity of the air* during any given interval of time may be deduced.

Measurements of evaporation within the thermometer shelters are difficult to make so as to be intercomparable at temperatures above and below freezing, and may be replaced by computations based on the wet-bulb temperatures. The absolute amount of evaporation from natural surfaces not protected from wind, rain, sunshine, and radiation, are being made at a few experimental stations and will be discussed in special contributions.

Sensible temperatures.—The sensation of temperature experienced by the human body and ordinarily attributed to the condition of the atmosphere depends not merely on the temperature of the air, but also on its dryness, on the velocity of the wind, and on the suddenness of atmospheric changes, all combined with the physiological condition of the observer. A complete expression for the relation between atmospheric conditions and nervous sensations has not yet been obtained.

PRECIPITATION.

[In inches and hundredths.]

The *distribution of precipitation* for the current month, as determined by reports from about 2,500 stations, is exhibited on Chart III. The numerical details are given in Tables I, II, and III. The total precipitation for the current month was heaviest over small regions in Florida, North and South Carolina, Tennessee, Virginia, eastern Pennsylvania, West Virginia, western Pennsylvania, Indiana, Illinois, Iowa, and northern Missouri, in all of which totals of 10 inches or more were reported. It was least, viz, inappreciable, over the greater part of California, Washington, and Oregon, and was less than 1 inch nearly everywhere in Nevada, Idaho, and western Montana. The larger values at regular stations were: Louisville, 13.0; Mobile and Tampa, 12.3; Parkersburg, 11.5; Kittyhawk, 10.0.

Details as to *excessive precipitation* are given in Tables XII and XIII.

The *diurnal variation*, as shown by tables of hourly means of the total precipitation, deduced from self-registering gauges kept at the regular stations of the Weather Bureau, is not now tabulated.

The *current departures from the normal precipitation* are given in Table I, which shows that precipitation was in excess in the Ohio Valley and the interior of the Atlantic States. It was deficient in the lower Mississippi and Arkansas valleys, the upper Lake Region, Washington, and Oregon. The large excesses were: Louisville, 9.2; Parkersburg, 7.1; Hannibal, 6.3; Columbus, Ohio, 6.2; Concordia, 6.1; Springfield, Ill., and Mobile, 5.8; Pensacola, 5.0. The large deficits were: Port Eads, 6.7; Meridian, 5.8; Vicksburg, 3.8; Fort Smith, 3.7; New Orleans, 3.6.

The *average departure* for each district is also given in Table I. By dividing these by the respective normals the following corresponding percentages are obtained (precipitation is in excess when the percentages of the normals exceed 100):

Above the normal: New England, 106; middle Atlantic,

119; south Atlantic, 120; Florida Peninsula, 125; Ohio Valley and Tennessee, 196; lower Lake, 175; upper Mississippi, 147; Missouri Valley, 112; northern Slope, 136; middle Slope, 146; southern Slope, 222; southern Plateau, 190; middle Plateau, 292; northern Plateau, 120.

Normal: South Pacific, 100.

Below the normal: East Gulf, 92; west Gulf, 61; upper Lake, 93; North Dakota, 42; north Pacific, 3; middle Pacific, 9.

The years of greatest and least precipitation for July are given in the REVIEW for July, 1890. The precipitation for the current month was the greatest on record at: Tampa, 12.30; Parkersburg, 11.46; Columbia, S. C., 10.89; Concordia, 9.27; Springfield, Ill., 8.15; Toledo, 6.65; Cheyenne, 6.35; Northfield, 5.99; Nantucket, 4.12; Lander, 3.00; Carson City, 0.63; Fresno, 0.07. It was the least on record at: Meridian, 1.12; Vicksburg, 1.09; Sault Ste. Marie, 0.96; Little Rock, 0.86; Fort Smith, 0.72; Neah Bay, 0.08; Astoria, 0.01; Port Angeles and Fort Canby, 0.00.

The total accumulated monthly departures from normal precipitation from January 1 to the end of the current month are given in the second column of the following table; the third column gives the ratio of the current accumulated precipitation to its normal value.

Districts.	Accumulated departures.	Accumulated precipitation.	Districts.	Accumulated departures.	Accumulated precipitation.
	Inches.	Per cent.		Inches.	Per cent.
Florida Peninsula	+ 1.50	106	New England	- 3.40	87
Lower Lake	+ 2.10	110	Middle Atlantic	- 0.10	100
North Dakota	+ 1.40	111	South Atlantic	- 4.00	87
Upper Mississippi	+ 1.00	105	East Gulf	- 5.00	86
Missouri Valley	+ 0.70	103	West Gulf	- 7.40	72
Northern Slope	+ 0.30	102	Ohio Valley and Tenn.	- 2.80	91
Southern Plateau	+ 0.50	112	Upper Lakes	- 2.60	86
Middle Plateau	+ 2.20	128	Middle Slope	- 1.30	91
North Pacific	+ 4.30	112	Abilene (southern Slope) ..	- 4.50	70
Middle Pacific	+ 2.60	114	Northern Plateau	- 0.70	94
			South Pacific	- 1.90	77

HAIL.

The following are the dates on which hail fell in the respective States:

Alabama, 22, 31. California, 20, 24, 27, 28. Colorado, 8, 9, 10, 13, 15, 17, 19, 21, 24, 25, 27, 28, 30. Connecticut, 13. Georgia, 18, 31. Idaho, 1, 12, 27, 29. Illinois, 21, 25, 26. Indiana, 3, 23, 28, 29, 30. Iowa, 21, 26, 27, 31. Kansas, 9, 28. Kentucky, 2, 4, 28, 30. Maryland, 27, 28, 29. Massachusetts, 3, 29. Michigan, 4. Minnesota, 2, 11, 12, 14, 19. Missouri, 4, 15, 31. Montana, 1, 2, 26, 29. Nebraska, 26, 28, 31. Nevada, 8, 11, 21, 23, 25, 29, 30. New Jersey, 30. New Mexico, 10, 28. New York, 3. North Dakota, 12, 17, 28. Ohio, 2, 6, 14, 27, 28, 30. Oregon, 11. Pennsylvania, 13, 23. South Dakota, 10, 14, 18, 25, 26, 28, 29. Tennessee, 2. Texas, 4, 6, 16. Utah, 13 to 17, 22, 26. Virginia, 28. West Virginia, 29. Wisconsin, 3, 14, 26, 29. Wyoming, 21.

WIND.

The prevailing winds for July, 1896, viz, those that were recorded most frequently, are shown in Table I for the regular Weather Bureau stations.

The resultant winds, as deduced from the personal observations made at 8 a. m. and 8 p. m., are given in Table IX. These latter resultants are also shown graphically on Chart IV, where the small figure attached to each arrow shows the number of hours that this resultant prevailed, on the assumption that each of the morning and evening observations represents one hour's duration of a uniform wind of average velocity. These figures indicate the relative extent to which winds from different directions counterbalanced each other.

HIGH WINDS.

Maximum wind velocities of 50 miles or more per hour were reported during this month at regular stations of the Weather Bureau as follows (maximum velocities are averages for five minutes; extreme velocities are gusts of shorter duration, and are not given in this table):

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
		Miles				Miles	
Amarillo, Tex.	14	56	w.	Pensacola, Fla.	7	72	n.
Cleveland, Ohio	26	66	w.	Philadelphia, Pa.	27	53	n.
Kittyhawk, N. C.	16	54	w.	Sioux City, Iowa.	26	52	nw.
New York, N. Y.	27	50	nw.				

SUNSHINE AND CLOUDINESS.

The quantity of sunshine, and therefore of heat, received by the atmosphere as a whole is very nearly constant from year to year, but the proportion received by the surface of the earth depends upon the absorption by the atmosphere, and varies largely with the distribution of cloudiness. The sunshine is now recorded automatically at 17 regular stations of the Weather Bureau by its photographic, and at 24 by its thermal effects. At one station records are kept by both methods. The photographic record sheets show the apparent solar time, but the thermometric sheets show seventy-fifth meridian time; for convenience the results are all given in Table XI for each hour of local mean time.

Photographic and thermometric registers give the duration of that intensity of sunshine which suffices to make a record, and, therefore, they generally fail to record for a short time after sunrise and before sunset, because, even in a cloudless sky, the solar rays are then too feeble to affect the self-registers. If, therefore, such records are to be used for determining the amount of cloudiness, they must be supplemented by special observations of the sky near the sun at these times. The duration of clear sky thus specially determined constitutes the so-called twilight correction (more properly a low-sun correction), and when this has been applied, as has been done in preparing Table XI, there results a complete record of the clearness of the sky from sunrise to sunset in the neighborhood of the sun. The twilight correction is not needed when the self-registers are used for ascertaining the duration of a special intensity of sunshine, but is necessary when the duration of cloudiness is alone desired, as is usually the case.

The average cloudiness of the whole sky is determined by numerous personal observations at all stations during the daytime, and is given in the column "average cloudiness" in Table I; its complement, or percentage of clear sky, is given in the last column of Table XI.

COMPARISON OF DURATIONS AND AREAS.

The sunshine registers give the durations of effective sunshine whence the duration relative to possible sunshine is derived; the observer's personal estimates give the percentage of area of clear sky. These numbers have no necessary relation to each other, since stationary banks of clouds may obscure the sun without covering the sky, but when all clouds have a steady motion past the sun and are uniformly scattered over the sky, the percentages of duration and of area agree closely. For the sake of comparison, these percentages have been brought together, side by side, in the following table, from which it appears that, in general, the instrumental records of percentages of durations of sunshine are almost always larger than the observers' personal estimates of percentages of area of clear sky; the average excess for July, 1896, is 11 per cent for photographic and 12 per cent for thermometric records.

The details are shown in the following table, in which the stations are arranged according to the greatest possible duration of sunshine, and not according to the observed duration as heretofore.

Difference between instrumental and personal observations of sunshine.

Stations.	Apparatus.	Total possible duration for the whole month.	Personal estimated area of clear sky.	Instrumental record of sunshine.			
				Photographic.	Difference.	Thermometric.	Difference.
Bismarck, N. Dak.	P.	479.6	50	83	+4	87	+5
Helena, Mont.	P.	479.6	67	73	+6	87	+5
Portland, Oreg.*	P.	475.7	82	87	+5	87	+5
Eastport, Me.	P.	471.7	40	51	+11	87	+5
Minneapolis, Minn.	T.	471.7	40	51	+11	87	+5
Northfield, Vt.	P.	468.4	35	45	+10	87	+5
Portland, Me.	T.	468.4	37	45	+10	87	+5
Rochester, N. Y.	T.	465.2	58	64	+6	87	+5
Buffalo, N. Y.	T.	465.2	41	51	+10	87	+5
Boston, Mass.	T.	461.8	46	56	+10	87	+5
Chicago, Ill.	T.	461.8	58	68	+10	87	+5
Cleveland, Ohio	P.	461.8	46	56	+10	87	+5
Des Moines, Iowa.	T.	461.8	59	69	+10	87	+5
Detroit, Mich.	T.	461.8	59	69	+10	87	+5
Dubuque, Iowa	T.	461.8	44	54	+10	87	+5
Eureka, Cal.	P.	458.6	39	49	+10	87	+5
New York, N. Y.	T.	458.6	54	64	+10	87	+5
Salt Lake City, Utah.	T.	458.6	40	50	+10	87	+5
Columbus, Ohio.	T.	455.2	37	47	+10	87	+5
Denver, Colo.	P.	455.2	55	65	+10	87	+5
Philadelphia, Pa.	T.	455.2	37	47	+10	87	+5
Baltimore, Md.	T.	455.0	37	47	+10	87	+5
Cincinnati, Ohio	T.	455.0	54	64	+10	87	+5
Kansas City, Mo.	P.	455.0	52	62	+10	87	+5
St. Louis, Mo.	T.	455.0	56	66	+10	87	+5
Washington, D. C.	P.	455.0	49	59	+10	87	+5
Dodge City, Kans.	P.	450.1	55	65	+10	87	+5
Louisville, Ky.	T.	450.1	51	61	+10	87	+5
San Francisco, Cal.	T.	450.1	67	77	+10	87	+5
Fresno, Cal.	T.	447.4	88	98	+10	87	+5
Santa Fe, N. Mex.	P.	444.5	37	47	+10	87	+5
Little Rock, Ark.	T.	442.0	54	64	+10	87	+5
Atlanta, Ga.	T.	439.7	47	57	+10	87	+5
Wilmington, N. C.	T.	439.7	42	52	+10	87	+5
Phoenix, Ariz.	P.	437.2	50	60	+10	87	+5
San Diego, Cal.	P.	437.2	66	76	+10	87	+5
Savannah, Ga.	P.	434.5	46	56	+10	87	+5
Vicksburg, Miss.	T.	434.5	85	95	+10	87	+5
New Orleans, La.	T.	429.6	65	75	+10	87	+5
Galveston, Tex.	P.	427.4	68	78	+10	87	+5

* Record by both methods.

ATMOSPHERIC ELECTRICITY.

Numerical statistics relative to auroras and thunderstorms are given in Table X, which shows the number of stations from which meteorological reports were received, and the number of such stations reporting thunderstorms (T) and auroras (A) in each State and on each day of the month, respectively.

Thunderstorms.—The dates on which reports of thunderstorms for the whole country were most numerous were: 3d, 224; 4th, 202; 13th, 209; 15th, 338; 22d, 205; 27th, 247.

Thunderstorm reports were most numerous in: Illinois, 239; Iowa, 201; Missouri, 275; North Carolina, 241; Ohio, 482; Pennsylvania, 202.

Thunderstorms were most frequent in: North Carolina, 31 days; Colorado, 30; Georgia and New Mexico, 29; Florida and South Carolina, 28; Kansas, Tennessee, and Texas, 27.

Auroras.—The evenings on which bright moonlight must have interfered with observations of faint auroras are assumed to be the four preceding and following the date of full moon, viz, from the 20th to the 28th, inclusive. On the remaining twenty-two days of this month 104 reports were received, or an average of about 5 per day. The date on which the number of reports especially exceeded this average was: 11th, 58.

Auroras were reported by a large proportion of observers in: Montana, 38; North Dakota, 28; Wisconsin, 17 per cent.

Auroras were reported most frequently in: Montana and North Dakota, 6 days; New Jersey, Ohio, and Wisconsin, 4 days.

CANADIAN REPORTS.

Thunderstorms were reported as follows: St. Johns, 11th; Grindstone, 15th; Halifax, 31st; Grand Manan, 13th; Yarmouth, 13th, 15th, 16th; St. Andrews, 11th, 13th; Charlottetown, 13th, 16th; Chatham, 2d, 12th; Father Point, 12th, 22d; Quebec, 12th, 17th, 22d, 27th, 30th; Montreal, 5th, 6th, 13th, 15th, 22d, 30th; Rockcliffe, 22d; Toronto, 6th, 12th, 28th, 29th; Port Stanley, 4th, 13th, 14th, 15th, 26th to 29th, 31st; Saugeen, 4th, 13th; Parry Sound, 9th, 14th, 22d; Port Arthur, 2d, 12th, 22d, 26th; Minnedosa, 4th, 14th, 15th, 17th, 19th; Qu'Appelle, 16th, 19th, 29th; Medicine Hat, 1st, 2d, 16th; Swift Current, 1st, 7th, 9th, 12th; Calgary, 24th, 28th; Prince Albert, 8th, 16th, 24th, 30th, 31st; Battleford, 8th, 10th, 16th.

Auroras were reported as follows: Sydney, 11th; Grand Manan, 11th; Charlottetown, 11th; Father Point, 11th; Quebec, 10th, 11th, 13th, 23d, 31st; Montreal, 11th; Toronto, 11th; Winnipeg, 2d, 6th; Minnedosa, 4th, 8th, 10th, 11th, 12th; Prince Albert, 3d.

INLAND NAVIGATION.

The extreme and average stages of water in the rivers for the current month are given in Table VIII, from which it appears that the Congaree, at Columbia, S. C., rose to 3.2 above danger line on the 8th, and the Willamette, at Portland, Oreg., rose to 8.5 above danger line on the 3d. In addition to these the Wabash, at Mount Carmel, Ill., was within 0.7 of the danger line from the 29th to 31st, and the Savannah at Augusta was within 2.4 of danger on the 10th. The Missouri at Kansas City was within 1.9 on the 6th.

LOCAL FLOODS.

Very many reports of high water and great damage due to local rains in small streams have come to hand; these are summarized in the following brief list arranged by dates. Most of these reports are culled from telegrams in the daily papers and are liable to occasional errors of one day.

5th.—Bellair, Belmont County, Ohio; Ohio and Marshall counties, and Moundsville, W. Va.; Pipe Creek, Ohio, opposite Moundsville; Four Mile, near Jackson, Ohio; Frankfort, Ky.
6th.—New York, N. Y., and vicinity; Newark and Flemington, N. J.; Laurel Hill, L. I.

10th.—Iredell, Yadkin and Catawba Rivers, Scotland Neck, Tillery, and Roanoke River, N. C.

12th.—Weldon, N. C.

14th.—McArthur, Ohio; Pittsburg and Alleghany City, Pa.; Phoenix, Ash Fork, Martinez, Congress, and Kyrene, Ariz.

15th.—Pittsburg, Alleghany City, Turtle Creek, Wilmerding, Greensburg, Export, Delmont, and Crabtree, Pa.; New York, N. Y.; Grantsville, Yellow Creek, Carrollton (7.30 p. m.), Marietta, and Lima, Ohio.

18–19th.—Kansas City, Kans. (local paper called this a cloud-burst, although only three inches of rain fell in two hours); Warrensburg, Macon, Shelby, Blue Springs, and Hannibal, Mo.; Warsaw, Valparaiso, and Anderson, Ind.; Fairbury and Percy, Ill.; Erie, Pa.

20th.—Portsmouth, Bowling Green, Wood County, and Wauseon, Ohio; Pittsburg and Alleghany City, Pa.; Centralia, Ill., 20th, 10 p. m. to 21st, 10 a. m., very heavy rain; Evansville (8.25 a. m. of the 20th to 8 a. m. of 21st, heavy rain), and Brazil, Ind.

20th–21st.—Bensons Creek, four miles from Frankfort, Shelbyville, Lexington, Louisville, Shelby, Fayette and Woodford counties, Lawrenceburg, Ky.; Manchester, Newton, Winchester, Aberdeen, and West Union, Ohio.

21st.—Jackson, Oak Hill, Batavia, and Lima, Ohio; Des Moines, Iowa; Rockford, Ind.; Parkersburg, W. Va.

20th–22d.—Cumberland, Md.; Clarksburg, Piedmont, and Buckhannon, W. Va.; Womelsdorf, Pa.

22d.—Fort Wayne, Ind.; Findlay, Ohio (8.45 a. m. until noon).

21st–23d.—Muncie, Ind.; Springfield, Grafton, Caldwell, Zanesville, Dayton, Marietta, Portsmouth, Shawnee, London, and Newark, Ohio; Richmond, Ky.; Pittsburg, Pa.; Sisterville, Charleston, and Parkersburg, W. Va.

23d.—Ashland, Ky. (2.45 p. m. violent storm of rain passed 19 miles west of Ashland and 2 miles east of Denton).

23d–24th.—Somerset (rainfall 6 inches), Stockport (eight inches), South Charleston, Springfield (23d, 10 p. m., cloudburst), Enon, Osborne, Cold Springs, Durboin, Eagle City, Tremont City, Shattuck, Lima, Tadmire, Fremont, Findlay, Lancaster, Caldwell (23d, 11 p. m., to 24th, 8 a. m.), Zanesville, Dayton, Grove City, London, Newark, and Shawnee, all in Ohio.

24th.—Morrison and Golden, Colo., and Bear Creek and Mount Vernon canyons, near Denver. This storm apparently extended from Boulder to near Pueblo; rained hard in Pueblo all day, beginning at 4 p. m., and very severe after 7; Warsaw and Arcola, Ill.; Terre Haute, Ind. (minor tornado at 3 a. m.); flood in the Monongahela, the worst for twenty-five years; Wheeling, W. Va. (2 a. m., to 2 p. m., heavy rain for the second time within three days); Gallipolis, Ohio (20–24th, rain every day and night for five days); Shawnee, Ohio (24th a. m., very hard rain and wind, the hardest ever known); New Lexington, Ohio (23d, 11 p. m., to 24th, 7 a. m.); Harrisburg, Ohio (23d, 9 p. m., to 24th, 6 a. m.); Marietta and Zanesville, Ohio (23d–24th, heaviest rains ever known); Beverly, W. Va.

25th.—Braddock, Pa., 4.45 p. m. heavy rain began; Port Perry, Pa. (heavy rain in the valley of the Monongahela, 70 miles above this place, and great flood here).

26th.—Dubuque, Iowa, worst storm on record; a rain in the morning, another in the afternoon, and a violent storm of wind and rain in the evening; the neighboring country generally flooded, with loss of bridges and crops.

26–27th.—Delaware, Ohio, heavy rain last night; the farmers say that the excess of rain this year is more disastrous than the drought of 1895.

27th.—Port Perry, Pa. (very violent); McKeesport, Pa., 4

p. m. (heavy rain, great damage); Homestead, Pa. (heavy rain began with strong wind between 4 and 5 p. m.; raining heavily until 10 p. m.); Elkhorn, Pa. (no storm on the 25th, but very heavy between 9 p. m. and midnight July 27th; terrible rain).

27–28th.—Pittsburg and Alleghany counties, and Cecil, Washington Co.; West Newton, Buena Vista, Perryopolis, Uniontown, Westmoreland, Grove City, Beaverfalls, Brownsville, Philipsburg, Jeannette, Indiana Co., Bellefonte, Irwin, Washington, McDonnell, Mount Pleasant, all in Pennsylvania (severe wind and rain, sometimes described as a cloudburst).

28th.—Frankfort, 10 p. m., 27th to 7 a. m., 28th; Elwood, Fowler, Newcastle, and Anderson, violent rain and hail during the night (six inches of rain supposed to have fallen); Tipton, Frankton, Noblesville, Bluffton (one hail-stone weighed one pound and seven ounces); Crawfordsville, Arcadia, Muncie (frightful wind); Montpelier (hailstones 17 inches in circumference); Rushville (4.40 p. m. rain and hail); Cicero, Lebanon, Lafayette, Terre Haute, (hailstorm, 4 p. m.); Kokomo; all in Indiana.

29th.—Chillicothe, Ohio; Glouster, Athens Co., Ohio (8 p. m., destructive gales from northwest and southwest, possibly a tornado and rain); Columbus, Ohio (small tornado 29th, p. m.); Circleville, Ohio; South Charleston and Germantown, Ohio (destructive wind); Blendon, Franklin Co., Ohio (7.30 p. m., violent wind and rain); Pleasantville, Ohio (8 p. m., tornado); Mentone, Ind. (tornado, 3 p. m.); Portland, Ind. Uniondale, Ind. (destructive wind); Bluffton, Ind. (destructive wind); Geneva, Ind., destructive wind.

30th.—Salem (two storms, early a. m. and noon); Portsmouth, Ohio, and the Scioto Valley (p. m.); Steubenville, Ohio (2.15 to 2.50 p. m. cloudburst, $3\frac{1}{2}$ inches); Stockport, Ohio (violent wind and rain); Briggsdale, Ohio (most violent wind and rain); East Liverpool, Ohio (2.30 p. m., cloudburst); Springfield, Ohio (p. m. whirling tornadic wind and rain); Alliance, Ohio (noon and 2 p. m. two heavy thunderstorms); Portsmouth, Ohio (29–30th fierce storm); 5 miles north of Delaware, Ohio (cloudburst); Jackson, Ohio (29–30th, heavy rain and wind); Harrisburg, Ohio (29–30th windstorm at night); Pickerington, Ohio (incipient tornado, at night 29–30th); Delaware, Ohio (6 p. m., small cloudburst); Glenville, W. Va.

31st.—Martins Ferry, Ohio (began 4 a. m., lasted thirty minutes).

CLIMATE AND CROP SERVICE.

By JAMES BERRY, Chief of Climate and Crop Service Division.

The following extracts relating to the general weather conditions in the several States and Territories are taken from the monthly reports of the respective services.

Snowfall and rainfall are expressed in inches.

Alabama.—The mean temperature was 80.9°, or 3.0° below normal; the highest was 105°, at Asheville on the 29th and 30th and Tuscaloosa on the 31st, and the lowest, 50°, at Madison on the 9th. The average precipitation was 5.06, or 0.66 above normal; the greatest monthly amount, 12.57, occurred at Newton, and the least, 105, at Uniontown.

Arizona.—The mean temperature was 83.3°, or 3.3° above normal; the highest was 120°, at Texas Hill and Fort Mohave on the 14th, and the lowest, 45°, at Flagstaff on the 27th and 29th. The average precipitation was 3.10, or 1.90 above normal; the greatest monthly amount, 6.92, occurred at Walnut Ranch, and the least, "trace," at Parker.

Arkansas.—The mean temperature was 83.5°, or 3.3° above normal, the highest July mean during the past fourteen years; the highest was 110° at Malvern, on the 31st, and the lowest 52°, at Silver Springs on the 9th. The average precipitation was 1.61, or 2.30 below normal; the greatest monthly amount, 7.50, occurred at Corning; Elon reported no rain. The drought that prevailed over all but a small area in the north-east part of the State, together with the very high temperature and hot

drying winds, did irreparable injury to all growing crops. Cotton, which at the beginning of the month never showed a better prospect for a very large yield, had, through shedding and premature opening of bolls, so deteriorated that at the end of the month there was but a very poor crop in sight. Corn was seriously injured and almost a total failure in many localities. The hay crop is short, pastures drying up, and stock water very scarce. The "oldest inhabitants" report the drought the most severe since 1874.

California.—The mean temperature was 76.6°, or 3.5° above normal; the highest was 124°, at Volcano Springs on the 12th, and the lowest, 27°, at Quincy on the 28th. The average precipitation was 0.09, or 0.04 above normal; the greatest monthly amount, 2.57, occurred at Isabella; numerous places reported no rainfall.

Colorado.—The mean temperature was slightly above normal; the highest was 104°, at Minneapolis on the 22d, and Lamar on the 29th, and the lowest, 28°, at Gunnison on the 21st. The average precipitation was 2.32, or 0.05 below normal; the greatest monthly amount, 5.00, occurred at Lake Moraine, and the least, 0.07, at Vilas.

Florida.—The mean temperature was 81.4°, or 1.2° below normal; the highest was 103°, at McClenny on the 30th, and the lowest, 57°, at Tallahassee on the 7th. The average precipitation was 8.18, or 1.36 above normal. The greatest monthly amount, 19.97, occurred at Milton, and the least, 2.43, at Merritts Island. The hurricane that swept the west-ern portion of the State on the 7th was one of the severest in the his-

tory of the service, and did incalculable damage to the various crops of the extreme western counties. The damage was particularly great in Escambia County. Cotton and corn were prostrated, and nearly all fruit was ruined. The heavy rainfall, in conjunction with the wind, made conditions worse, and many fields were badly washed.

Georgia.—The mean temperature was 80.0°, which is normal; the highest was 105°, at Millen on the 30th, and the lowest, 49°, at Diamond on the 15th. The average precipitation was 8.26, or 3.10 above normal; the greatest monthly amount, 13.10, occurred at Toccoa, and the least, 2.44, at Millen.

Idaho.—The mean temperature was 71.0°; the highest was 107°, at Payette and Pollock on the 5th, and the lowest, 31°, at Chesterfield on the 24th. The average precipitation was 0.73; the greatest monthly amount, 1.86, occurred at Idaho City, while no rain fell at Minidoka.

Illinois.—The mean temperature was 75.2°, or 0.7° below normal; the highest was 106°, at Mascoutah, and the lowest, 39°, at Chemung. The average precipitation was 6.35, or 3.34 above normal; the greatest monthly amount, 12.14, occurred at Atwood, and the least, 2.20, at Herrin.

Indiana.—The mean temperature was 75.0°, or 0.4° above normal; the highest was 100°, at Angola on the 3d, Evansville and Huntington on the 30th, and Vincennes on the 27th and 29th, and the lowest, 42°, at Hammond on the 16th. The average precipitation was 7.61, or 4.27 above normal; the greatest monthly amount, 12.78, occurred at Angola, and the least, 2.88, at Huntington.

Iowa.—The mean temperature was 73.6°, or 0.5° below normal; the highest was 104°, at Malvern on the 3d, and the lowest, 42°, at Elkader and Mason City on the 7th, 9th, and 17th. The average precipitation was 6.90, or 2.60 above normal; the greatest monthly amount, 12.67, occurred at Moor, and the least, 1.61, at Rock Rapids.

Kansas.—The mean temperature was 78.1°, or 0.5° above normal; the highest was 108°, at Winfield on the 30th, and the lowest, 48°, at New England Ranch on the 23d. The average precipitation was 4.75, or 1.25 above normal; the greatest monthly amount, 10.96, occurred at Wakefield, and the least, 0.90, at Morton and Tribune.

Kentucky.—The mean temperature was 77.4°, or 1.1° above normal; the highest was 103°, at Sandy Hook on the 1st, and at Paducah on the 30th, and the lowest, 47°, at Maysville on the 1st. The average precipitation was 7.44, or 3.06 above normal; the greatest monthly amount, 13.01, occurred at Louisville, and the least, 2.76, at Princeton.

Louisiana.—The mean temperature was 83.2°, or 1.7° above normal; the highest was 109°, at Liberty Hill and Oakridge on the 31st, and the lowest, 53°, at Amite and Davis on the 9th. The average precipitation was 2.36, or 3.46 below normal; the greatest monthly amount, 7.76, occurred at Cameron, while no rain fell at Lake Providence, Minden, and Monroe. The month was the driest July on record since State observations began. The lack of rainfall in the northern parishes was disastrous to all vegetation, and, combined with the extreme heat of the latter part of the month, served to burn up pastures and work material harm to the cotton and corn crops, causing the former to shed and open prematurely, and the latter to wilt.

Maryland.—The mean temperature was 76.0°, or 0.9° above normal; the highest was 99°, at Western Port on the 13th, and Wilmington, Del., on the 29th, and the lowest, 40°, at Deer Park and Sunnyside on the 17th. The average precipitation was 5.22, or 1.45 above normal; the greatest monthly amount, 15.27, occurred at Sunnyside, and the least, 2.34, at Easton.

Michigan.—The mean temperature was 69.1°, or 0.2° below normal; the highest was 98°, at Baraga, on the 1st, and at Port Austin, Fitchburg, and Adrian on the 2d; the lowest was 32°, at Powers on the 17th. The average precipitation was 3.47, or 1.38 above normal; the greatest monthly amount, 8.88, occurred at Hanover, and the least, 0.60, at Northport.

Minnesota.—The mean temperature was 69.9°; the highest was 100°, at Lesueur, Granite, and Glenwood on the 12th, and at Bingham Lake on the 14th, and the lowest, 36°, at Breese on the 23d. The average precipitation was 1.88; the greatest monthly amount, 4.39, occurred at Mount Iron, and the least, 0.33, at Cambridge.

Mississippi.—The mean temperature was 82.9°, or 1.6° above normal; the highest was 106°, at Columbus on the 28th, and the lowest, 50°, at Corinth on the 9th. The average precipitation was 2.19, or 1.65 below normal; the greatest monthly amount, 6.55, occurred at Leakesville, and the least, 0.16, at Austin. At many places in the western portion the fall was equally as light as that at Austin, and the severe drought which was almost universal in that section injured cotton and corn and all minor crops which promised well at the beginning of the month. Cotton began to open prematurely and cotton picking was the earliest of record, the "first bale" was received at Vicksburg on the 22d.

Missouri.—The mean temperature was 77.2°, or 0.1° above normal; the highest was 108°, at Grovedale on the 31st, and the lowest, 48°, at Houston on the 8th, and at Potosi and Mount Vernon on the 9th. The average precipitation was 5.75, or 1.84 above normal; the greatest monthly amount, 14.98, occurred at Downing, and the least, 1.51, at Mineral Spring.

Montana.—The mean temperature was 68.0°, or about normal; the highest was 111°, at Musselshell on the 9th, and the lowest, 30°, at

Marysville on the 21st. The average precipitation was 1.26, or 0.56 above normal; the greatest monthly amount, 4.95, occurred at Fort Custer, and the least, "trace," at Troy.

Nebraska.—The mean temperature was 74.3°, or 0.5° below normal; the highest was 109°, at Norman on the 26th, and the lowest, 44°, at Lexington on the 10th. The average precipitation was 3.87, or 0.36 above normal; the greatest monthly amount, 9.52, occurred at Odell, and the least, 0.53, at Culbertson.

New England.—The mean temperature was 70.0°, or 0.8° above normal; the highest was 96°, at Lewiston, Me., and North Conway, N. H., on the 2d, and the lowest, 39°, at West Milan, N. H., on the 24th. The average precipitation was 3.66, or 0.06 below normal; the greatest monthly amount, 6.67, occurred at Falls Village, Conn., and the least, 1.34, at Providence, R. I.

New Jersey.—The mean temperature was 75.0°, or 0.5° above normal; the highest was 98°, at Millville on the 29th, and the lowest, 47°, at Charlotteburg on the 1st and 26th. The average precipitation was 5.50, or 1.18 above normal; the greatest monthly amount, 13.29, occurred at Belvidere, and the least, 2.45, at Camden.

New Mexico.—The mean temperature was slightly below normal; the highest was 104°, at Rincon on the 8th, and the lowest, 34°, at La Belle on the 10th. The precipitation was abundant; the greatest monthly amount, 8.77, occurred at Winsors Ranch, and the least, 0.73, at Olio.

New York.—The mean temperature was 70.7°, or 0.7° above normal; the highest was 95°, at Avon on the 2d, and Middletown and Plattsburg Barracks on the 3d, and the lowest, 40°, at Friendship on the 17th and 18th, and Saranac Lake on the 31st. The average precipitation was 4.85, or 1.19 above normal; the greatest monthly amount, 8.71, occurred at Port Jervis, and the least, 2.43, at North Hammond.

North Carolina.—The mean temperature was 77.4°, or 0.2° below normal; the highest was 103°, at Tarboro on the 30th, and the lowest, 44°, at Highlands on the 9th. The average precipitation was 8.19, or 2.67 above normal; the greatest monthly amount, 13.77, occurred at Flat Rock, and the least, 3.23, at Selma. July was remarkable for its excessive rains and the great heat during the latter part. The average precipitation for the month, 8.19, is the highest on record for North Carolina during twenty-five years. The heaviest rains occurred on the 7th and 8th, and some of the amounts were very large. A rapid rise occurred in the streams over the entire State with an enormous amount of damage to lowland crops, especially corn.

North Dakota.—The mean temperature was 67.5°, or 1.1° below normal; the highest was 107°, at Medora on the 11th, and the lowest, 31°, at Dickinson on the 27th. The average precipitation was 1.59, or 1.27 below normal; the greatest monthly amount, 4.78, occurred at Wahpeton, and the least, 0.47, at Minto.

Ohio.—The mean temperature was 73.2°, or 0.3 above normal; the highest was 102°, at Warsaw on the 27th, and the lowest 40°, at Annapolis on the 17th. The average precipitation was 8.11 (the wettest month on record), or 4.63 above normal; the greatest monthly amount, 16.13, occurred at Demos, and the least, 3.60, at Orangeville. The continued wet weather, storms, and floods proved very damaging to crops on lowlands. Oats and wheat in stack and shock were seriously injured by too much rain.

Oklahoma.—The mean temperature was 82.0°; the highest was 109°, at Anadarko on the 24th, and the lowest, 54°, at Beaver on the 4th. The average precipitation was 2.96; the greatest monthly amount, 6.14, occurred at Winnview, and the least, 0.35, at Tahlequah.

Pennsylvania.—The mean temperature was 72.8°, or 1.7° above normal; the highest was 98°, at Aqueduct on the 13th, and the lowest, 40°, at Smethport and Shinglehouse on the 17th, and Confluence on the 21st. The average precipitation was 6.89, or 2.59 above normal; the greatest monthly amount, 15.59, occurred at Lycippus, and the least, 3.04, at Coatesville.

South Carolina.—The mean temperature was 80.7°, or 0.9° above normal; the highest was 105°, at Gillisonville and Shaws Forks on the 31st, and the lowest, 51°, at Walhalla on the 8th. The average precipitation was 8.17, or 2.15 above normal; the greatest monthly amount, 15.72, occurred at Greenwood, and the least, 3.42, at St. Stephens.

South Dakota.—The mean temperature was 71.0°, or about normal; the highest was 108°, at Forest City on the 2d, and the lowest, 35°, at Parkston on the 8th, 16th, 24th, and 25th. The average precipitation was 2.80, or 0.16 below normal; the greatest monthly amount, 6.82, occurred at Shiloh, and the least, 0.14, at Nowlin.

Texas.—The temperature on an average for the State was 0.2° below the normal. There was a general deficiency over central and west Texas, the Panhandle, and the western portion of north Texas, and along the coast, which ranged from 1.0° to 4.0°, with the greatest deficit in the vicinity of El Paso. Over the other portions of the state there was a general excess, ranging from 0.3° to 0.8° over east and southwest Texas, and from 1.1° to 2.5° over the eastern portion of north Texas, with the greatest in the vicinity of Paris. The maximum was 108°, at Camp Eagle Pass on the 4th; minimum, 52°, at Sierra Blanca on the 6th. The average precipitation for the State was 0.02 below the normal. There was a general excess over the Panhandle, west and southwest Texas, and the coast district, with the greatest more than 4.0 in the vicinity of Amarillo. Over the other portions of the State there

was a general deficiency, ranging from 0.2 to 0.92 over central and east Texas, and from 0.26 to 1.40 over north Texas, with the greatest in the vicinity of Paris. The greatest monthly precipitation was 7.23 at Stafford.

Utah.—The mean temperature was 72.0°, or about 1.0° below normal; the highest was 111°, at St. George on the 11th, and the lowest, 33°, at Soldier Summit on the 1st. The average precipitation was 1.81; the greatest monthly amount, 3.85, occurred at Koosharem, and the least, 0.12, at Cisco.

Virginia.—The mean temperature was 76.3°, or about normal; the highest was 102°, at Bonair on the 28th, and the lowest, 42°, at Blacksburg on the 8th. The average precipitation was 6.99, or 3.38 above normal; the greatest monthly amount, 11.23, occurred at Spottsville, and the least, 3.35, at Birdsneet.

Washington.—The mean temperature was 68.2°, or 3.3° above normal; the highest was 112°, at Bridgeport, Fort Simcoe, and Connell, and the lowest, 37°, at Blaine on the 29th, and Hunters on the 22d. The average precipitation was 0.06, or 0.50 below normal; the greatest monthly amount, 0.60, occurred at Rosalia; no rain fell at more than half of the stations. The chief characteristic of the month of July, 1896, was the general absence of precipitation. Seldom, if ever, has there been such a protracted drought in the eastern section, and in the western section there has been but one like it since the settlement of the country; that was in 1883. This year, at 80 per cent of the stations no rain at all fell, or only the slightest trace. The drought begun in June, there having been scarcely any rain after the 9th. In the eastern section of the State there were a few scattered thunderstorms during the month of July.

West Virginia.—The mean temperature was 73.2°, or about 2.0° below normal; the highest was 97°, at Hewett on the 29th, and the low-

est, 46°, at Beckly on the 10th, and Bloomery on the 18th. The average rainfall was 9.07, or nearly 5.0 above normal; the greatest monthly amounts were 15.70, at Phillippi; 15.60, at Beverly; 15.15, at Weston, and 15.09, at New Martinsville. The least amount was 2.91 at Green Sulphur Springs. Exceedingly heavy rains occurred in the northern-central and Ohio Valley counties, and in other sections the rainfall was considerably above the normal. The rivers of the northern part of the State were flooded to a height greater than ever before known at this period of the year, and very great damage was done to crops and property along their courses and on lowlands. In many localities the crops were totally destroyed, and in all sections were more or less injured by the wet weather. These storms were generally electrical, and in some cases exhibited tornadic tendencies. The observer at Beverly reports the occurrence, on the 24th, of the most disastrous storm that ever visited that valley, and at Glenville, on the 30th, a storm occurred which was said to have been the severest ever known in that locality, and which exhibited the character of a tornado. The heaviest of these storms occurred from the 13th to 16th, the 21st to 25th, and on the 28th and 30th.

Wisconsin.—The mean temperature was 69.8°, or less than 1.0° below normal; the highest was 100°, at Medford on the 3d and Osceola Mills on the 12th, and the lowest, 34°, at Antigo on the 16th. The average precipitation was 3.15, or slightly less than normal; the greatest monthly amount, 8.30, occurred at Delevan, and the least, 0.7, at Pepin.

Wyoming.—The mean temperature was 68.0°, or about normal; the highest was 102°, at Lusk on the 13th, and the lowest, 32°, at Wheatland on the 14th. The average precipitation was 2.04, being decidedly above normal; the greatest monthly amount, 6.35, occurred at Cheyenne, and the least, 0.52, at Wheatland.

SPECIAL CONTRIBUTIONS.

KITES IN MONTANA.

By Mr. A. B. Coe.

From recent letters received from Mr. R. M. Crawford, director of the Montana section of the Climate and Crop Service, and from Mr. A. B. Coe, voluntary observer at Kipp, Montana (N. 48° 45', W. 112° 45', elevation about 4,000 feet), we take the following notes, and hope that others may be led to pursue similar studies with the same enthusiasm. Mr. Coe says:

I herewith transmit an account of a little experiment tried recently, employing a cellular kite of the dimensions described in the November, 1895, WEATHER REVIEW for the purpose, and my maximum thermometer.

A phase of our climate at this station is the frequent veering of the wind from westerly points to north or northeast, accompanied by an extremely rapid fall of temperature, and usually more or less precipitation.

I have often thought that these cold waves did not reach very high up, and that at no great height above them the warm southwest wind still prevailed. For several days prior to July 29, 1896, my maximum had been climbing up into the nineties too frequently for comfort. The air was dense with smoke, when the wind suddenly veered to the northeast, blowing steadily at about 15 or 20 miles an hour, and pretty thoroughly clearing the atmosphere of smoke. The temperature fell 51° in the next twenty-four hours, and on the 21st the clouds were dragging on the ground, and precipitating both rain and snow. At 11.30 a. m., on that date, my minimum thermometer registered 32°, but only for about twenty minutes, when it rose to 38°. From occasional glimpses of the sun obtained through breaks in the clouds, and from its red appearance, it was evident that there was another current of air full of smoke at a low altitude, blowing from the west, and undisturbed by the cold wave from the northeast beneath it.

The time and circumstances seemed propitious to test my theory, so I climbed to the top of a hill near my home, which I found by triangulation to be about 200 feet above my usual place of observation. Thither I bore my tailless kite, maximum thermometer, and 4,800 feet of No. 24 twine, tagged at every 100 feet for convenience in computing elevation. I secured the thermometer firmly in a pasteboard tube, open at both ends, and fastened this to my kite with wire. At 1.15 p. m. the surface temperature was 38°, when with the help of an assistant I soon had both kite and instrument mounting steadily upward on a flight of exploration.

I will have to add right here, that my kite is a "stayer," and the only one of any description I ever made that would fly. I let it run out 1,000 feet, and on drawing it in found that there was no difference in its registration. Again I let it out, and it was not until 3,900 feet of twine had unreeled that any change in its action was observed; then

I noticed that the kite above the fog and clouds was pulling nearly northeast, instead of southwest, as at first. Upon pulling it in, during which operation it again assumed its strain to the southwest, I was overjoyed to discover that the register stood at 77°, while at the point where I stood it remained at 39°. Being anxious to make sure that there was no mistake, I sent the instrument up again, and obtained a like result at about the same altitude, the kite going through the same movements as at first; but whether my observation is of any value aside from the personal satisfaction derived, is a question.

I anticipate some interesting experiments this coming winter in this direction, to determine, if possible, at what elevation the warm winds locally termed "chinooks" blow, at times when their influence is felt many miles east of this point, while remaining intensely cold here.

In response to a request for further data as to the protection of his thermometer and other matters, Mr. Coe writes:

I employed a strong pasteboard tube 12 inches in length, and 1½ inch in diameter for the purpose. In this I sewed my maximum thermometer securely with strong pack thread, and packed fine cotton around each end for the better protection of the tube. Directly over the tube I cut a slit ¼ by 8 inches, so that the scale could be readily seen without removing the instrument. Four feet from the belly band I secured the tube to the twine with fine wire. The wind was blowing a good stiff breeze at the time, probably 20 miles an hour, and from the time the kite was let go until pulled in 23 and 25 minutes, respectively, elapsed, and the difference in temperature at each trial was the same as stated. My kite rose and descended very steadily without diving or pitching, so that I could not well believe that the difference in temperature was caused by any condition other than an upper current of warm air, blowing from the southwest at that altitude. The clouds near the earth were very dense, while from another experiment tried at the same time, I am satisfied that the kite passed through the clouds into bright sunshine. I secured a strip of sensitized paper between two thin pieces of mica, and sent it up attached to the kite, and exposed a similar piece to the light on the ground, in a like manner to protect the paper from dampness. While the paper at my feet remained unchanged in color to any extent the piece sent up was changed to a bronze black.

SUNSHINE AT THE SOUTHERN CALIFORNIA AGRICULTURAL EXPERIMENT FARM, NEAR POMONA, CAL.

By Mr. A. J. HENRY.

The percentages of sunshine for the six months, January to June, 1896, at the Southern California Agricultural Experiment Farm are given in the table below. The data are published as compiled in the Records Division of the Weather Bureau, from the original photographic sheets made under the direction of Mr. J. W. Mills, foreman of the experiment

station, and furnished to the Weather Bureau through the courtesy of Prof. E. W. Hilgard, director, Berkeley, Cal. No corrections have been applied to the records. Pomona, Cal., is in latitude N. 34° 3'.

Hourly percentages of possible sunshine near Pomona, Cal.

Month.	Percentages of possible sunshine recorded during the (local mean time) hours ending—														Hours of sunshine.		
	A. M.							P. M.							Total actual observed.	Total possible.	Percentage of possible.
	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7			
1896.															<i>Hrs.</i>	<i>Hrs.</i>	
January			20	40	56	66	66	56	69	70	71	36	.....	.....	176.0	316.2	56
February	4	32	73	86	90	89	87	88	88	88	74	11	.....	.....	238.6	318.5	75
March	16	53	65	73	76	77	72	68	70	67	62	22	.....	.....	222.9	372.3	60
April	6	51	67	69	80	77	84	81	76	80	84	85	69	7	273.3	391.6	70
May	3	46	68	78	82	90	85	81	84	83	83	85	79	10	297.1	432.6	69
June	7	53	43	62	74	81	87	94	96	96	99	96	93	30	296.7	431.5	76

KITE EXPERIMENTS AT THE WEATHER BUREAU.

By C. F. MARVIN, Professor of Meteorology, U. S. Weather Bureau.
(Continued from the June Review.)

EFFICIENCY.

Hitherto no exact and scientific methods appear to have been employed to determine the relative merits of different kites, or to fully measure and analyze their action. Experimenters in general have been contented to make a rough estimate by eye of the angular elevation attained, or if this has been measured the results, with rare exceptions, have been inaccurate, and the observations limited to a very small number. Often, probably, but a single reading has been made at a favorable moment when the kite had momentarily attained an extreme elevation. Moreover, the observations have generally been made with the object of ascertaining the altitude of the kite when a long length of deeply sagging line was out. Little or no notice appears to have been given to the effect of the long line in modifying the angular elevation of the kite. If any accurate measurements of the behavior of kites have been systematically made such measurements have, with one or two exceptions, been conspicuously absent from any published accounts of kite experiments known to the writer. It is therefore impossible to form any estimate of the relative merits of the kites employed by different individuals. Eye observations without the aid of instruments suffice to determine only general qualities of steadiness, etc. Those factors upon which the usefulness of a kite for meteorological purposes depends, namely, the *lift* and *drift*, can be determined accurately only by aid of instrumental measurements. Eye estimates of the angular elevation of kites tend nearly always to exaggerate the amount of the angle, and data of this sort respecting the behavior of kites can have no place in scientific investigations.

Various methods of expressing numerically the merit of a given kite may be employed. The *lift* and *drift* may be made the measure of excellence of a given kite. But the *lift* and *drift* of a kite vary with every gust of wind, and it is difficult to deduce from these quantities a true numerical rating of the merit of a kite under examination. This objection to the use of *lift* and *drift* as a measure of excellence would have less weight if the wind blew with a steady direction and constant force, but this is never the case. Moreover the *lift* and *drift*, aside from depending directly upon the force of the wind, depend further upon both the actual surface of the kite and upon the angle of incidence. A very perfect kite which happened to be bridled in such a fashion that the angle of incidence was, for example, 25°, would, in all probability, show a smaller *lift* and a larger *drift* than a much inferior kite bridled so that its incidence was 15°. This difference of incidence would, in all probability, wholly escape the

notice of an ordinary observer unless his attention was specifically directed to discover it. Even if discerned with the eye the real numerical relation could be established only by carefully made instrumental observations. The *lift* and *drift* in themselves, therefore, do not constitute a suitable basis for a true numerical estimate of the useful effect available in a kite. They are in fact only conventional and derived ideas. We must go back of them to the fundamental forces from which they are derived for the basis upon which true comparisons can be made. *Efficiency* is the technical term widely employed in all branches of engineering to designate numerically the useful effect available in machines of any sort. Thus, we have the efficiency of a steam engine, of a boiler or furnace, the efficiency of electric generators, motors, converters, etc., so likewise we may have the efficiency of kites. This measure of merit, as adopted at the Weather Bureau for the comparison of kites with each other, is based upon fundamental mechanical principles, and is widely applicable to any kind of kite. The resulting measure is not directly dependent upon the angle of incidence of the kite or upon the direction or force of the wind.

Efficiency of kites.—The basis upon which any rating of efficiency is deduced is very largely a matter of choice. In dealing with machines and appliances for producing physical or mechanical effects, economical considerations have much to do with the ultimate or absolute utility of the devices employed. From the economic standpoint an efficiency rating is an exceedingly complex result, depending upon many factors of the most heterogeneous character—cost of space, wages of employees, cost of transportation, interest on investment, etc. These factors can be related to each other only in a highly arbitrary and empirical manner. The efficiency of mechanical devices, as the term is ordinarily used, is not generally deduced upon the economical basis but depends upon purely mechanical and physical considerations of cause and effect. Dismissing economics we will likewise define the efficiency of kites upon the physical and mechanical basis. Even here, choice may be made among several methods. We may consider that the most efficient kite is one which can attain the highest elevation. As we shall see hereafter, the elevation attained by a kite is purely a question of the forces acting upon the string. It is very plain that to make the efficiency of a kite depend in any way upon the string is not desirable. Even if we eliminate, as we may, effects due wholly to the string, and make the efficiency of the kite depend upon its power to attain elevation, we still make a bad choice, for we would thereby fail to consider that kites may be employed for other purposes than attaining elevations. A highly efficient kite from such a standpoint would be highly inefficient if it were employed to pull sleds or carry a line ashore from a stranded vessel.

A basis upon which the efficiency of a kite can be deduced, that is not open to such objections as raised above, may be had by considering only the *inclination of the total resultant wind pressure* to the surface of the kite. A kite, fundamentally, is a surface either plane or curved against which it is designed the wind shall press. The ideal kite is that surface; the actual kite is a material substance having thickness, edges, possibly a tail, etc. The string is an entirely separate accessory not necessarily included in discussing efficiency. In the analysis of the action of the wind upon surfaces a principle of efficient action was pointed out on page 162,¹ as follows: "The condition of ideal efficiency (that is, an efficiency of 100 per cent), in the action of the wind upon thin plane surfaces, obtains when the total resultant pressure is exactly normal to the surface." Recognizing that a kite is a surface against which the wind shall press, we say broadly that the pressure is most efficiently exerted when for plane surfaces the total pressure is exactly normal to the surface. For arched sur-

¹ MONTHLY WEATHER REVIEW, May, 1896.

faces we must deal with inclinations to a tangent, or more conveniently to the chord of the arch. We will speak of this more in detail further on.

The reader who has followed the section on the "Analysis of forces" in the May REVIEW (page 157) and who has in mind the effects of the weight of the kite as set forth on page 203 of the June REVIEW is prepared to readily understand the application of the above-mentioned principles to the derivation of the efficiency of a kite. Under ideal conditions, that is, conditions in which edge pressures, surface or skin friction, waviness and fluttering, eddy effects, etc., are wholly absent, it follows as a direct consequence of the principles already established that the ideal kite, whose weight is considered inappreciable as compared with the wind pressure, will fly in such a manner that the direction of the string next the kite will make an angle of 90° with the surface of the kite or with the longitudinal axis thereof. In the case of an actual kite of appreciable weight and more or less imperfect in other respects, it will be found upon measurement that the direction of the string next the kite will make an angle of less than 90° with the longitudinal axis. This angle between the direction of the string next the kite and the longitudinal axis of the kite is properly made the numerator of the efficiency ratio, and for convenience and brevity we will call it hereafter the *efficiency angle*. It is the angle AOR in Fig. 65. If, upon measuring the angle between the direction of the wire and the kite, it were found to be 75° , for example, then the efficiency of the kite would be given by the ratio of this angle to 90° , that is—

$$\text{Efficiency} = 75 \div 90 = 83\frac{1}{3} \text{ per cent.}$$

This measurement relates specifically to the *position* the kite takes in the air, and does not deal with the *pull* of the kite. We might, therefore, more specifically call the above defined efficiency the *position efficiency*. The *pull* is a factor wholly independent of the *position* when we consider simply the mechanics of a kite, and it is well to keep these factors separate in estimating the merits of kites.

The different positions that kites of different efficiencies assume when flying from a string which is either so light or so short that it does not sag to an appreciable extent is shown in Fig. 65. AB represents the midrib or longitudinal axis of a kite; and the string is supposed to make an angle of 75° therewith, corresponding to a position efficiency of $83\frac{1}{3}$ per cent. The angle of incidence of the horizontal wind with the kite is supposed to be 20° . In such a case the angular elevation of the kite will be 55° . If, however, the kite were perfect, in which case the efficiency angle would be 90° , the position the kite would then take is shown at $A'B'$, and its angular elevation would be 70° instead of 55° , the kite still retaining the same angle of incidence of 20° . It might be argued that by changing the angle of incidence of the kite AB by the proper amount without changing its efficiency it would fly as high as $A'B'$. This may be true, but the more efficient kite would pull harder, and if its angle of incidence were likewise changed, the perfect kite would again fly higher than the imperfect kite and pull equally hard.

The foregoing treatment of the question of the position efficiency of kites applies strictly only to plane surface kites, and throughout all preceding discussions where efficiency angles have been measured in reference to a midrib or longitudinal axis of the kite it has been assumed, as was generally the case in the Weather Bureau kites, that the *apparent angle of incidence* was also the *true angle of incidence*.¹ If this is not at least approximately so in a given kite, or if, as in a trapezoidal kite, the sustaining surfaces are at different angles of incidence, then the efficiency angles must be taken in reference to the planes themselves.

Arched surfaces.—When we deal with arched surfaces some

experimental results show that the wind forces in question do not act in the same manner as upon plane surfaces, and while the general principles involved in deducing efficiency still remain the same, a slight change in computing it numerically will probably be required, owing to the fact that in the ideal case the string might form with the longitudinal axis an angle— AOR , Fig. 65—greater than 90° .

The difficulty in the case of arched surfaces is that we do not know, a priori, the maximum possible angle between the string next the kite and the surfaces, or the chord of the arc; that is, we have no certain value for the denominator of the efficiency fraction. Some observations show that the angle ought to be greater than 90° in the ideal case, but just how much greater is not known. This is a matter which is at present of minor importance. In fact, this angle undoubtedly varies with every modification of the curvature of the arch, and possibly with changes in the angle of incidence. While, therefore, we may not be able to arrive at a mathematically correct numerical value of the *efficiency ratio* in the case of arched surfaces, we still have in the *efficiency angle* alone a wholly satisfactory basis for numerically rating the merit of any kite, whether with flat or with arched surfaces. The most efficient kite, other things remaining the same, is the one showing the maximum efficiency angle. The experiments up to July 1 had not been carried sufficiently far to show the most satisfactory procedure in the case of arched surfaces. The foregoing remarks refer to the *position efficiency* of kites. Let us consider briefly the pulling power of kites.

Pull.—In comparing the pulls of different kites, the comparison must, of course, be made always for the same conditions; that is, for the same velocity of the wind, the same angle of incidence, and the same unit of surface. There is very little reason why kites should differ much in the pull per square foot of surface if we have been careful to measure the sustaining surface upon a systematic basis, such as already explained in the REVIEW for June, page 201. The following appear to be the principal causes why one kite should pull more than another under otherwise similar conditions: Arching the surfaces of the kites, as we have already explained, may increase the pull very greatly. In kites of the cellular type the sheltering of one surface by another may diminish the pull per unit area, more or less. The pervious character of ordinary cloth may serve to diminish the pull. The wind may not press to good advantage upon the pointed lateral and bottom extremities of such kites as the Malay, and the pull may be less in consequence.

Efficiency—how determined.—Having defined the mechanical significance of the efficiency of kites, the next point is how shall the necessary measures be made in order to compute the efficiency in a given case. The only quantity which it is necessary to measure is the angle between the wire and the kite. It would not be difficult to construct a small recording instrument which, when connected between the bridle and the main wire, would produce a continuous record, from which the angle between the main wire and one of the bridle lines could be deduced. Since the angles between the bridle and the kite may always be known, the record mentioned would suffice completely to give the desired efficiency angle. This sort of an instrument could be combined with a small dynamometer recording the pull of the kite upon the same record sheet with the efficiency angle. If still further combined with a recording anemometer, the resulting apparatus would constitute a complete *kite indicator*, since it would give the principal elements required in working out the efficiency of kites and the action of the forces thereon. It was not considered advisable to attempt to introduce such an instrument for recording the elements mentioned, although the matter received serious consideration, and the dynamograph portion of the instrument for recording the pull of the line, either at the kite or at the

¹ Page 201, MONTHLY WEATHER REVIEW, June, 1896.

reel, was actually constructed. This instrument is shown in Fig. 68 and is described on page 241.

Incidence scale.—In the absence of the instruments required for making the above described automatic record of the efficiency angle, another method was devised for measuring by eye observations, not only this angle, but the angle of incidence of the kite and, simultaneously, its angular elevation. This method is best explained in connection with a kite with rectangular cells. By aid of a stencil made from a sheet of oil-board paper a series of graduation lines 1 inch apart are boldly marked in black upon the white cloth of one of the upper sustaining surfaces of the cell, usually the forward cell, as shown in Fig. 66. The lines are one-quarter inch broad, and each fifth line is about 2 inches longer at each end than the intermediate lines, which are about 4 inches long.

The zero line of the scale is at the front edge of the cell. Figures need not be applied to any of the lines, as the grouping in fives renders the reading of the scale sufficiently easy and certain. The scale, for convenience, may be called the incidence scale, since by its use we ascertain the angle of incidence of the kite.

When a kite of the usual proportions provided with such a scale is flying in a normal manner, and is viewed from a position near the reel, a part only of the incidence scale is visible, the remainder being concealed behind the lower surface of the cell. At a distance of a few hundred feet the number of divisions of the scale exposed to view can be read with the unassisted eye, but in our regular experiments a small reading telescope, such as employed by physicists for reading galvanometer scales, etc., has been used. The telescope for the purpose was mounted upon an ordinary engineer's tripod. Easy motion in both altitude and azimuth was provided, and in the absence of a regular vertical circle an accurately divided draughtsman's protractor was arranged to give the angular elevation of the axis of the telescope. Assisted by the telescope, readings of the incidence scales have been made with as much as 2,000 feet of wire out, but in order to eliminate from the observations as much as possible the effect of the sag in the wire, which had to be taken into account in the manner hereafter described, observations were nearly always made at distances of between 400 and 1,000 feet.

The protractor was divided to half degrees, and readings of less than this amount could be made. Owing, however, to the constant and great changes of the position of the kite, refinement in angular readings, when working at short range, possess no significance. For the same reasons the estimates of the incidence scale were confined in general to half inches. To offset the coarseness of these measures observations were repeated at intervals of from 30 to 60 seconds, and ten or more readings made in each set from the mean of which the final deductions were made.

The act of making an observation consists in bringing the kite in view in the telescope, and following its motions until at a favorable moment a reading of the scale can be satisfactorily made with the kite near the center of the field. The inclination of the telescope at this moment is the angular elevation of the kite, which is thus determined simultaneously with the scale reading. Fig. 67 shows the relation of the angles in question. The angle A at the kite is the observed angle of elevation; i is the desired angle of incidence; the angle x is given by the equation:

$$\tan. x = \frac{s}{h}$$

in which h is obtained from the known height of the cell and s is the reading of the incidence scale.

Finally, $i = 90^\circ - (A + x)$.

If we were justified in neglecting the sag in the wire, then the efficiency angle between the wire and the kite would be—

Efficiency angle = elevation + incidence.

Generally, however, we will desire to be more accurate than to neglect the sag in the wire. The data for making the necessary allowance for the sag of the wire is obtained if, at the moment the scale reading is made with the telescope, an assistant observes the inclination of the wire at the reel. In a subsequent section the mathematical equations of the curve assumed by the kite wire will be discussed at length, and it will be shown that when the sag in the wire at the reel is known the sag next the kite can be found. For the present we will call these angles S' and S , and they are so marked in Fig. 67. With the kite at a distance of 400 feet or more from the reel, lines of sight, such as RV and $R'V'$, will be sensibly parallel, although they are not so in the drawing, owing to the exaggerated size of the kite. In practice, observations are made only when the sag in the wire is slight, in which case the angles S and S' are nearly equal to each other. Owing to the peculiar character of the curve assumed by the wire, the angle S will be smaller than S' as a rule. The efficiency angle, including the sag, is

$$A + i + S.$$

Inclination of wire at reel.—As stated above, the sag of the wire is obtained from a measurement of the inclination of the wire at the reel. This was measured by means of a protractor, arranged to hang over the wire with its diameter parallel thereto, and provided with a light hand or index pivoted at the center of the arc and always assuming a vertical direction, thus serving to indicate on the graduated arc the angle of inclination of the wire. This angle subtracted from the angular elevation of the kite, measured from a point carefully chosen just at one side of the reel, gives the angle S' . In strong winds the position of the index of the protractor was sometimes affected, and it was necessary to weight the index with a small plumb-bob. Finally, the whole protractor was inclosed in a glass case.

Probable errors.—By means of the telescope and incidence scale simultaneous observations of the angular elevation and incidence of the kite are made in a highly satisfactory manner. Owing to the great variations of the wind the incidence is found to vary considerably, as also the position of the kite. Observations must be made quickly and at favorable moments. The measurement of the incidence angle is less accurate in proportion as the scale reading is small. An error amounting to a whole inch in a single reading of the scale can not be made except by gross mistake, and the error of the mean of several readings is probably less than 0.5 of an inch. The corresponding error in the angle, under conditions found in practice may, in extreme cases, be as much as 2° . Repeated observations of the same kite on different days have been so consistent with each other that it is believed the errors are actually less than those just described. If a satisfactory measure is not obtained in the manner described it is necessary simply to move the telescope back from the reel a short distance, so as to obtain such an angle of view as TT' , Fig. 67, resulting in more accurate measures. If efficiency tests are to be made at the same time, then an additional measurement of the angular elevation of the kite from a point near to and at one side of the reel will also be required.

General remarks on efficiency.—The manner we have chosen for deducing the efficiency of a kite is such that the weight of the kite is a modifying factor, causing the efficiency to be less than would be the case if the efficiency were made to depend only upon such imperfections as edge pressures, skin friction, waviness, eddies, etc. To include the effect of the weight with that of the imperfections just mentioned is, we believe, a very proper course, inasmuch as the kite must first

sustain its own weight before it is available for rendering useful services. Moreover, if for analytical purposes it is desired to study separately the imperfections mentioned above, the precise knowledge we may always have of the weight of a kite enables us, by the aid of simple mechanical principles and the resolution of forces, to perfectly separate the effects due to weight and other disturbing influences, so that each may then be studied separately.

Weight and efficiency.—On page 203 of the June REVIEW the modifications produced in the direction of the string next the kite, due to the weight of the kite and different wind velocities, were fully pointed out. We now notice also that every change in the angle of the string means a corresponding change in the efficiency angle, which is the angle $A O H$, $A O H'$, $A O H''$, etc., Fig. 63.¹ From a consideration of these points we see that owing to effects arising from its own weight the efficiency of a kite in light winds is less than in heavy winds. In Fig. 63 it was assumed that the direction of the resultant pressures $O Q$, $O Q'$, $O Q''$, etc., corresponding to increasing wind forces, remained always at the same angle with the kite surface. This will be the case when the influences due to edge pressures, waviness, eddies, etc., follow exactly the same law of increase as obtains for the normal wind pressure. This seems likely to be the case with edge pressures, perhaps, but it is probable that the detrimental effects of eddies and fluttering are proportionally greater at high than at low velocities. It may, therefore, happen that a kite seriously defective in respect to these last-mentioned imperfections would, with moderate wind forces, show increasing efficiency up to a certain point, but that in still stronger winds the efficiency would actually become less. In other words, the strong wind would seem to blow the kite down. Such an instance has not come within my own observation, but its probability is easily seen from a physical standpoint.

Incidence and efficiency.—The pressure of the wind upon the kite may be feeble, not alone because of light wind velocities, but also by reason of the kite flying at small angles of incidence. If the incidence is made too small the pressure of the wind even at considerable velocities will be only a relatively small multiple of the weight, and this condition, as we have found, results in only small angular elevations. There is, in fact, a particular incidence giving a maximum effect. This is treated of further on, in the section on the catenary.

Ascending air currents.—Thus far it is assumed, in computing the incidence and efficiency of kites, that the wind flows in horizontal streams. This is generally, but not always, the case. It is well known that masses of air generally have a descending or ascending as well as a horizontal motion. Under these circumstances the actual direction of motion of the air may be in lines that are upwardly inclined to an appreciable extent. Kites are very sensitive to such conditions and the action of such ascending currents causes the kite to soar up to an unusually high angular elevation. The keen observer will not be misled into believing, as some have, that the phenomenal behavior of a kite under such influences is due to some peculiar excellence of the kite itself. These effects of ascending currents were well known and understood by the scientific kite flyers of half a century ago. A brief quotation in regard thereto is cited in the April REVIEW, page 114, mentioning the experiences of the Franklin Kite Club.

If a kite flying normally in a horizontal wind assumes an angle of incidence of, say 15° , then in an ascending current flowing in a direction inclined upwardly at an angle of 10° the same kite would seem to assume an angle of incidence of only 5° and would soar to a point near the zenith, although still flying at an angle of incidence of 15° .

When the bridle adjustment of a kite remains fixed, the angle of incidence of the kite will also remain constant with a given wind force. Even with different wind forces, unless

they are very feeble, the incidence will change, but very little. Furthermore, the efficiency angle of a given kite is a definite angle, which must remain nearly constant in the same kite so long as it is not modified in any way or the wind force is not too feeble. Since, as we have just seen, the incidence and efficiency angles of a kite must be constant with given conditions, it necessarily results that the angular elevation will also be constant. When, therefore, we have fully established the constants of a given kite by careful measurements under normal conditions of longitudinal air motion, the behavior of the kite under abnormal conditions of ascending currents is, perhaps, one of the best measures we have of the amount of the abnormality. By means of a kite with its constants carefully determined, it thus seems possible to measure, with a fair approximation, the upward inclination of movements of masses of air otherwise quite inaccessible.

Causes of small efficiency.—We have found that when the wind pressure is several times the weight of the kite the influence of the weight on the efficiency angle is very small and unimportant. Results obtained with good kites under favorable conditions show that efficiencies of 90 per cent and over may be attained. When, therefore, we find, under favorable conditions of wind, smaller efficiencies than this, we know at once that the kite is either excessively heavy or defective in respect to edge pressures, waviness, eddies, etc., or the angle of incidence is too small, which latter is easily corrected by changing the bridle adjustment. An incidence of 15° is probably as small as can be employed with advantage, at least with flat surface kites. In the case of cellular kites, if the top and bottom surfaces are too near each other, or if the front and rear cells are too close together, the flow of the air through the structure of the kite may be, as it were, choked up to a greater or less extent. All such effects will have a direct influence on the efficiency.

From these brief remarks it is evident that in dealing with efficiency we have a powerful and searching artifice for numerically and justly expressing the merit of a given kite. It is hoped experimenters will familiarize themselves with the principles involved and apply them in general to kites of their own, so that some idea can be had of the real duty that a given kite has performed.

GENERAL OBSERVATIONS OF KITES.

While the measurements of the angles referred to in the preceding section are sufficient to establish the angle of incidence at which a given kite is flying, and to determine its position efficiency, still other observations are needed to ascertain all the facts we wish to know concerning the behavior of the kite. Among these the following are discussed:

Measurement of the tension of the wire.—Prior to July all measurements of tension of the wire at the reel consisted of eye readings of a spring scale attached to the reel in the manner described in the April REVIEW, page 122. The scale of the dynamometer employed embraced 50 pounds, and when the tension on the wire was greater than this limit a purchase (in the mechanical sense) was obtained by use of a movable pulley, the dynamometer being attached to one end of the cord passing over the pulley. This tackle, as is well known, multiplies effects by two; hence, the dynamometer which indicates normally only 50 pounds answers for a maximum strain of 100 pounds.

Dynamograph.—Fig. 58 represents a small dynamograph devised to give an automatic record of the tension of the wire. The clock is one of the very small, inexpensive house clocks on sale by any jeweler. But very little alteration is required to mount the clock on its hour-hand axis, which, being suitably prolonged, is clamped firmly in the bearings $A A$, with the result that the whole cylinder containing the clock revolves at the rate of one revolution per hour. In order to

¹ Fig. 63 will be found in the WEATHER REVIEW for June.

reduce to a minimum the motion of the moving parts concerned in measuring the tension, the spring employed is exceedingly stiff, being one of the excellent springs commonly used in steam engine indicators. A strain of 100 pounds compresses the spring about one-sixth of an inch. This motion is magnified and recorded with precision by the pen in a manner readily understood from the figure. The dynamograph in its original form was designed for use with small kites with pulls of not to exceed 35 pounds, whereas experiments were actually made requiring a greater range of scale. The necessary modifications in the dynamograph to adapt it to larger scales were not, however, made until after July 1.

Measurements of wind velocity.—No direct measurement of the wind velocity was made during the kite experiments except the continuous records made at the Weather Bureau. These records answered every purpose so far as the general experiments were concerned, but a much more specific and local measurement is greatly needed in order to formulate the laws connecting the pressures per unit area with the angles of incidence, velocity of wind, perviousness of cloth, character of kite, etc. A small anemometer weighing only 0.8 of a pound has been constructed which records, not by the usual step by step methods, but continuously every movement of the cups. Fractions of a mile at their true momentary velocities are fully recorded by it and momentary velocities for very brief periods have been deduced with the same accuracy as is attained in ordinary velocity measurements. This instrument was, however, not available for use until after July and its further description is reserved to accompany the publication of results we hope to attain by its use.

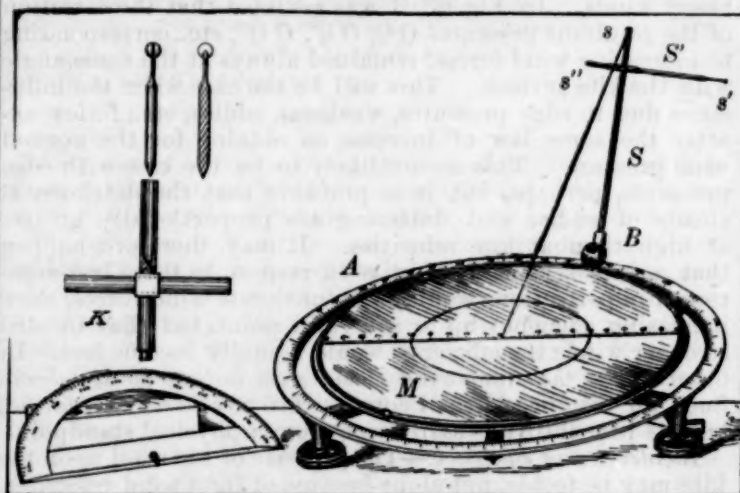
Measurements of angular elevation.—The manner of measuring the angular elevations of kites by aid of the telescope, as described in the section on efficiency, is not the most convenient when nothing but the angular elevation is needed nor is its accuracy all that can be desired in the case of lofty ascensions. Two other methods have therefore been employed.

Nephoscope.—It was often desired to ascertain the average position of a kite without observing necessarily its efficiency. Owing to the constant changes going on in the angular elevation of the kite the average must be based on numerous measurements made momentarily and at perfectly equal intervals of time. The best results are secured if the instrument employed admits of being read or at least set at a precise instant of time. This is the case with the nephoscope employed by the Weather Bureau for observing the positions and motions of clouds. It is shown in the illustration below and was described at length in the WEATHER REVIEW for January, p. 9.

Its manipulation is so simple that scarcely more than one second is required for ascertaining the angular elevation of a kite. The nephoscope is mounted upon a firm table or support near the reel and the mirror *M* carefully leveled by the aid of an ordinary level which accompanies the instrument. To observe the kite the eye is placed so that the former is seen reflected from the central spot of the mirror, and the sighting knob *s* on the staff *S* set so that the knob is also seen reflected at the center of the mirror. This setting can be made in a very short time. The angle of the inclined thread may then be measured with the protractor, and we have the angular elevation of the kite. Such settings of the nephoscope were generally made at exact intervals of thirty seconds for a period of five to ten minutes. The average of ten or twenty readings of this sort may be considered to give a close measure of the average position the kite under examination will take under ordinary conditions of atmospheric motion. Experimenters should not be satisfied with a less exact and truthful record of the average performance of a given kite than one obtained in some such way as that described.

Sextant.—The nephoscope answers admirably for the meas-

urement of angular elevation under most circumstances. In the case of lofty ascensions, however, the kite appears very tiny and is sometimes difficult to see. In order to measure the angular elevation accurately under such circumstances a sextant fitted with a low-power glass has been employed. A small plate-glass mirror about 12 inches square, mounted on three leveling screws, was used in place of the ordinary artificial horizon of mercury. The accuracy of this method of measuring the angular elevation is really more than demanded. It was not necessary to read the vernier of the graduated scale at all, as sufficient accuracy was attained by eye estimation of the minutes of the scale. By the optical principles involved in the use of the sextant with an artificial horizon the actual scale-reading gives double the angular elevation. At great heights the apparent position of a kite varies but little, nevertheless our practice has been to read angles at comparatively short intervals, so that a fair average position may be attained.



Marvin's Improved Nephoscope.

Calculation of height.—When the sag in the wire is disregarded the altitude of the kite is given by the equation:

$$H = r \sin A.$$

When *r* is the length of wire out and *A* is the angular elevation of the kite. This assumes that the length of a straight line from the reel to the kite is the same as the length of the wire itself, which of course can not be true. If, however, the sag in the wire is not over 20° at the reel, then roughly the straight line will be only about 2 per cent shorter than the wire. For a sag of 30° the difference will be about 4 per cent. The height, computed by the equation given above, should then be diminished by the proper percentage allowance for sag. Results obtained in this way will be quite as accurate as by more complicated methods of deducing the height by triangulation or by records of air pressure obtained from barographs attached to the kites. Other accurate methods of computing the height will be given in a subsequent section on the properties of the catenary, including the case of invisible kites.

RESOLUTION OF FORCES.

When the efficiency angle and pull are known for a given kite, also the bridle adjustment, we have the data for constructing a complete diagram of the actual forces acting on the kite. By way of illustrating more in detail how the analytical observations on kites have been conducted in the Weather Bureau investigations, and to show how the diagram of forces is constructed and the resolution of forces carried out in an actual case, the following observations from our field notebook are given:

Tests of kite No. 30, May 19, 1896 (see Table VI, Review for June, p. 201).

[Bridle adjusted as shown in Fig. 69; observations made with 700 feet of wire out.]

Time. p.m.	Pull.	Incidence scale.	Inclination of wire.	Elevation of kite.
<i>h. m. s.</i>	<i>Pounds.</i>		°	°
2 4 15*	20	2.5	.....	60.5
2 8 30	20	3.5	56.0	57.5
2 9 30	25	3.5	57.0	60.0
2 10 45	4	6.0	50.0	61.0
2 11 30	20	3.2	54.0	57.0
2 13 00	20	3.0	55.0	58.0
2 13 50	22	4.5	56.0	57.5
2 14 30	24	4.0	57.0	60.5
2 16 20	16	3.8	56.3	59.0
2 18 20	15	4.0	56.0	59.5
2 20 00	14	4.0	55.0	56.5
2 22 30	10	6.0	51.0	55.0
.....	24	5.0	54.0	55.0
Means.....	17.8	4.21	54.8	58.0

*This first observation, being incomplete, is omitted in taking the sums and means.

Results.—The height of the cell of this kite is 20 inches; therefore, the scale reading, 4.21, corresponds to an angle x given by the equation

$$\tan. x = \frac{4.21}{20} = 0.2105 \text{ whence } x = 11.9^\circ.$$

Hence, the incidence = $90^\circ - (58.0^\circ + 11.9^\circ) = 20.1^\circ$.

Sag of wire at reel = $58.0^\circ - 54.8^\circ = 3.2^\circ = S'$.

When the sag of the wire is small, as in this case, a close approximation to the sag at the kite, that is, the angle S is given by taking $S = 81\%$ of S' , therefore $S = 2.6^\circ$.

Hence, the efficiency angle = $58.0^\circ + 20.1^\circ + 2.6^\circ = 80.7^\circ$.

$$\text{Whence the efficiency} = \frac{80.7}{90} = 90\%.$$

This kite was observed later on the same day both by the telescope and nephoscope with 2,000 feet of wire out. The readings are given below.

Time. p.m.	Pull.	Incidence scale.	Inclination of wire.	Elevation of kite.
<i>h. m. s.</i>	<i>Pounds.</i>		°	°
3 44 10*	12	7	35	50.5
	23	6	45	52.0
	23	5	46	55.5
	18	5	46	58.0
	26	4	50	54.0
	30	4	50	54.0
	8	5	48	55.5
	24	5	45	52.5
	18	4	44	52.5
3 49 00*	18	5	47	53.0
Means.....	20.0	5.0	45.6	53.75

*Time of only first and last observations noted.

From these observations $x = 14.0^\circ$; incidence = 22.2° ; $S' =$ sag at reel = 8.2° ; $S = 6.6^\circ$; efficiency angle = 82.6° ; efficiency = 92%.

From observations with the nephoscope the following results were obtained—2,000 feet of wire out:

Time. P. M.	Pull.	Inclination of wire.	Elevation of kite.
<i>h. m. s.</i>	<i>Pounds.</i>	°	°
3 54 00*	16	42.0	52.0
	14	42.5	51.5
	10	46.0	53.5
	8	42.0	55.0
	16	41.0	51.5
	16	44.0	51.5
	8	40.0	52.5
	16	41.0	49.5
	10	47.0	55.0
	8	39.0	54.0
	12.2	42.45	52.60

* Every 30 seconds.

If we assume, as we are justified in doing, that the average incidence of the kite was the same as actually observed in the observations made a few moments before we shall have, incidence assumed to be 22.2° , sag in wire at reel, $S' = 10.2^\circ$; $S =$ approximately 8.1° ; efficiency angle = 82.9° ; whence the efficiency = 92%.

We have given above three separate sets of observations. The amount of variation in the efficiency angle that may be looked for under such conditions is shown in the three values, 80.7° , 82.6° , and 82.9° .

The pull on the wire was measured at the reel where it is less than the tension at the kite. The difference between the two will depend upon the relative inclination of the wire at kite and reel. The mathematical relation between the tensions at different points on the kite wire does not concern us at the present moment and is reserved for treatment in a subsequent section.

Diagram of forces.—Fig. 70 shows the actual diagram of forces corresponding to the results obtained from the first set of observations. The center of gravity of the kite is at the center of figure as at g . Passing a line through F so as to intersect the axis of the kite at the efficiency angle, viz, 80.7° , we have the line $LFOR$ which is the action line of the resultant of all the forces at the kite. To resolve this total resultant force into its components we draw a vertical line, gO , through the center of gravity of the kite and lay off thereon from O downward the line OG , representing on a convenient scale the weight of the kite = 3.59 pounds. From properties of the catenary it can be shown that when the tension of the wire at the reel is 17.8 pounds as observed in the present case the tension at the kite under the observed conditions will be 21.1 pounds. This force is represented by the line OR drawn to the same scale as OG . Completing the parallelogram of which OR and OG are the diagonal and one side, respectively, we have the line OQ which represents the total resultant of all the wind pressures upon the kite. By measurement we find this resultant to be 24.2 pounds and by prolonging its action line downward we find that it intersects the kite at an angle of 85.1° .

We wish now, from this diagram, to arrive at some idea as to the relative intensity of the wind pressure upon the front and rear cells of the kite. The front cell is freely exposed to the wind, while the rear cell is in some degree sheltered, and we may reasonably expect to find the pressures on the latter deficient. When we wish to represent by a single force the combined effect of the wind pressures upon both the upper and lower surfaces of a cell, the principles of mechanics lead us to locate the point of action of that single force midway between the surfaces, provided the upper and lower pressures are equal. If they are unequal, then the point of action must be proportionately nearer the greater force.

Now, in such a kite as that under consideration the upper and lower surfaces are separated by a distance a little greater than their width. In such a case it is believed the upper surface at ordinary wind velocities can not be sheltered to any large extent by the lower surface, and that the pressures on the two surfaces are sensibly equal, at least in so far as concerns the interference of one surface with the other. Nevertheless, in the case of the rear cell it is quite probable that the exposure of at least the upper surface is far from unobstructed, and the pressure of the wind upon the lower surface also may be slightly deficient by reason of the proximity of the front cell. Therefore, it is probable that the points of action of single forces representing the combined pressures upon the upper and lower surfaces of the cell can not with accuracy be placed midway between the surfaces; but our present purposes do not require that these points be located with great accuracy. It can be shown that little or no sensible error will be produced in the results we seek if we

assume, as we shall, that the points of action of the single forces in question fall midway between the upper and lower surfaces of each cell, as, for example, upon the line *CC* in Fig. 70.

Returning now to the resolution of the forces, we found from the diagram that the line *OQ* represented the total wind pressure upon the kite. This force is made up of the pressures upon the individual cells, and we have just found that the points of action of the pressures upon the individual cells may be assumed to fall upon the line *CC*. In accordance with the principles of mechanics, the point of action of the total resultant pressures will also fall upon the same line, *CC*. The point, in fact, will be at the intersection of the lines *OQ* prolonged, and *CC*; that is, at *O'*, and the total resultant is completely represented by the line *O'Q'*. This force, as just stated, is the resultant of two forces, one being the wind pressure upon the forward cell, the other the corresponding pressure upon the rear cell. Since the sustaining surfaces in the cells are equal, the wind pressures ought also to be equal, under the assumption that one cell does not shelter the other. Our diagram of forces enables us to discover the difference in the pressures on the two cells. To prevent confusion of lines, we will use in this study the diagram in Fig. 71, which represents the line *CC* of Fig. 70, and the force *O'Q'*. Before we can divide the force *O'Q'* into the two parts representing the wind pressures upon the front and rear cells, respectively, we must locate the centers of pressure in those cells. We can not do this very accurately, but the points of action of the forces are undoubtedly forward of the middle of the cell in each case. Several formulae based on experimental work have been given for computing the position of the center of pressure on a rectangular plane surface, and if we employ one of these we can not go very far astray. Chanute in "Progress in Flying Machines," gives the formula $d = l(0.2 + 0.3 \sin i)$. Applied to the present case, l is the width of the cloth bands in the kite under consideration, and i is the angle of incidence; d is the distance from the front edge of the surface to the center of pressure. Computing the result, we find $d = 5.8$ inches. By this method we locate the center of pressure in each cell at *P* and *P'*. Through the points thus found we draw the lines *PN* and *P'N'* parallel to *O'Q'* and proportional to the lines *O'P* and *O'P'* respectively. According to the well known principle of the lever, two forces represented by the lines *PN* and *P'N'* will be exactly equivalent to the single force *O'Q'*, and vice versa. That is to say, if *O'Q'* is known, then the forces *PN* and *P'N'* are those sought, and represent the forces on the two cells respectively. *PN* is a pressure of 18.5 pounds, while *P'N'* is only 5.67 pounds, which shows to how great an extent the rear cell is sheltered by the forward cell. If we assume that the action of the wind upon the forward cell is unimpeded and acts sensibly with the maximum effect, then the rear cell experiences only 31 per cent as much pressure as the front cell. In other words, the efficiency of the rear cell is only 31 per cent. These results depend in a manner upon an assumed position of the center of pressure within the cells. But any other logical assumption that one may desire to make concerning the position of the center of pressure will lead to results that do not differ greatly from those found above, and a noticeable disparity between the pressures upon the front and rear cell will still exist. If the center of pressure is placed nearer the center of each cell than we have assumed, then the disparity will be greater. If it is placed at the extreme front edge of the cell, which would be absurd, there would still be some disparity.

We see from the foregoing example, in which the resolution of the forces acting upon a kite have been worked out in detail, that the diagram of forces is a most powerful means of analysis. It has been the aim in the Weather Bureau in-

vestigations to exhaustively analyze the action of kites in the manner outlined above and thereby arrive at the best possible forms and proportions. With the limited time and means available for constructing kites and for preparing the apparatus and accessories required in making the observation, only partial solutions have thus far been reached, although the most gratifying improvements upon the original forms have even thus been effected. The line of study and experiment described above is better calculated to lead to improvements in kite flying than the simple flying of kites to just as great elevations as they can attain carrying meteorological instruments with them at the same time, so as to obtain atmospheric records. It is impossible by this latter method to analyze the action of the kite or to discover any except the most tangible and conspicuous imperfections. All the finer details leading to the development of the best forms and proportions of kites must always remain beyond the grasp of such experiments. Table IX contains the results of the efficiency tests made upon kites up to July 1, 1896.

TABLE IX.—Results of efficiency tests.

Date.	Kite.		Number of observations.	Amount of wire out.	Angular elevation of kite.	Inclinat'n of wire.		Incidence at kite.	Efficiency angle.	Efficiency.	Pull.
	No.	Kind.				At reel.	At kite.				
1896.				Feet.	°	°	°	°		%	lb.
March 26....	22	Three planes.	10	1,000	52.6	48.1	56.2	21.0	77.2	86	.....
April 28....	24	do	10	1,000	41.2	31.9	48.8	25.6	74.4	83	.....
May 11....	24	do	4	400	56.1	53.8	58.4	23.8	82.2	91	26
May 11....	24	do	10	400	57.6	54.0	60.5	23.8	84.3	94	27
May 15....	24	do	5	1,000	59.0	55.6	61.6	15.8	77.4	86	12
May 15....	24	do	10	1,000	61.0	57.1	64.2	16.0	80.2	89	15
April 22....	23	Two planes.	6	400	55.3	51.1	58.7	23.9	82.8	92	.....
April 21....	28	do	10	400	59.1	54.9	62.5	21.4	83.9	93	.....
April 21....	28	Trapezoid.	12	290	56.0	53.7	58.3	16.3	74.6	83	.....
April 21....	28	do	10	1,000	49.6	44.8	53.5	17.6	71.1	79	.....
April 22....	28	do	5	400	57.7	55.0	60.4	17.8	78.2	87	.....
April 30....	28	do	9	1,000	53.4	48.9	57.1	14.9	72.0	80	.....
May 11....	28	do	10	400	56.4	54.5	58.3	15.6	73.9	82	27
June 11....	28	do	10	571	48.2	45.3	50.5	19.0	69.5	77	28.2
June 11....	28	do	10	571	50.5	47.2	53.2	15.1	68.3	76	22.9
May 11....	19	Rect. struts.	14	400	46.6	41.9	50.5	17.9	68.4	76	8.6
April 28....	29	do	10	400	53.9	48.5	58.3	17.9	76.2	85	8.4
April 28....	29	Trapezoid.	10	1,000	45.0	36.7	51.7	18.3	70.0	78	.....
June 11....	29	do	10	571	53.5	50.0	56.3	15.5	71.8	80	31.1
June 11....	33	Rect. struts.	7	571	48.8	44.0	52.7	22.8	75.5	84	10.7
June 11....	35	Trapezoid	5	.....	46.7	40.0	53.4	14.7	68.1	76	3
May 19....	36	Rectangle.	12	700	58.0	54.8	60.6	20.1	80.7	90	17.8
	36	do	10	2,000	53.8	45.6	60.0	22.2	82.2	91	20.0
	36	do	10	2,000	52.6	42.4	60.2	22.2	82.4	92	12.2

* The kites in this table have the same numbers, respectively, as the corresponding kites in Table VI.

Bridle adjustment.—The adjustment of the bridle of the kite is not a matter of so much mystery and importance as is often supposed to be the case. It will be found, if proper experiments are made, that very much the same results can be obtained by the greatest variety of bridle arrangements, or even by discarding the bridle altogether. In the case of the kite shown in Fig. 70, exactly the same results would have been obtained if the bridle had been discarded and the wire attached directly to the kite frame at the point *S*. This, at least would be the case if there were no fluctuations in the wind, and its force and character had corresponded to the average of the observed variable wind. Likewise any one of many other forms of bridles, such as suggested by the several dotted lines in the diagram, might have been employed. The only condition which each of these arrangements must satisfy is that the point of attachment of the wire must fall upon the line *LO*.

Steadiness in position.—We have said there would be no differences arising from the use of any of the several arrangements of bridles suggested, provided there were no fluctuations in the wind. We may go still further and say that although the extreme positions of the kite corresponding to variations of the wind might differ considerably, depending upon the bridle, yet it is quite probable that the averages

would still be much the same. The complete analysis of this element of the kite problem is comparatively complex and a few important points only will be brought out here.

In the first place we have to deal with a highly complex set of variations of the wind. It will answer in the present discussion to consider only variations affecting considerable masses of air, such that the whole kite is subjected to uniformly changed conditions that persist long enough, at least, to permit the kite to assume a new position of equilibrium. These variations may be divided into two groups: (a) variations of direction, (b) variations of force. In treating of the variations under (a) we must consider not only the incessant changes in horizontal direction, but must also recognize and deal with similar changes that are likewise going on in an up and down sense. The motions of considerable masses of air may be either upwardly or downwardly inclined as well as horizontal.

The variations of force are of great complexity, but their general character is pretty well known to every observer and need not be detailed here.

Changes of horizontal direction.—The changes in horizontal direction of the wind cause the kite to shift from side to side. So long as we tie the bridle only to the midrib of the kite, as is nearly always done, at least with the malay and cellular kites, all sidewise tiltings of the kite must take place about that stick as the axis. It does not matter, therefore, so far as these tiltings are concerned, how the arrangement of the bridle may be changed in other respects. In their direct effect on the sidewise movements of the kite all bridles are the same so long as they are fastened to the same stick or midrib.

Variations of force and direction.—Variations of either force or direction of motion, if inclined upward or downward, tend to cause the kite to rise or fall. If the variation is only of the inclination of the direction of motion of the wind, then the new position of equilibrium for the kite flying on a short and straight string will differ from the old by an angular amount (if measured from the reel) sensibly equal to the change in the inclination of the wind's motion. These angular changes would be exactly equal if it were not for a secondary effect, due to the weight of the kite, that need not be now considered. For such variations of direction as just considered the arrangement of the bridle in a particular case can not have any direct influence on the behavior of the kite.

If the variation is one of wind force, then the bridle adjustment may have much to do with the amount by which the kite will change its position. When the force of the wind is considerable, variations of the force will cause but slight changes in position of the kite, however bridled. When the force is only moderate, variations thereof produce larger changes in the position of the kite, and in such cases the following statements set forth rather crudely certain results depending upon the bridle. When the bridle is short, that is, when the point of attachment of the main line is relatively close to the surface of the kite, the angular changes in the position of the kite depending upon variations of wind force will tend to be greater than when the bridle is longer. Discarding the bridle, which can be done in cellular kites, gives a minimum distance between the point of attachment and the front surfaces, and is apt to result in large changes in angular elevation of the kite when the force of the wind falls off greatly. With short bridles, the angle of incidence of the kite tends to be more nearly constant with different wind velocities. Being nearly constant, the variations of pressure upon the kite will be nearly as great as those of the wind; whereas, the longer bridle permits the angle of incidence to increase when the velocity of the wind diminishes, in consequence of which the variations in the pressure upon the kite are less than the variations in wind force.

REV—3

A very long bridle may produce conditions under which it is impossible for the kite to be in equilibrium.

The writer is accumulating numerical data by which the most useful proportions and disposition of the bridle in a given case can be fully established. As yet these studies have not been sufficiently advanced to justify more detailed statements than given above.

With a given form of bridle (preferably one in which neither of the angles next to the kite is a right angle), the angle of incidence of the kite will be made *smaller* if the point of attachment of the main line be shifted toward the *forward* end of the kite, and *vice versa*.

Lofty ascensions.—The favorable conditions of wind have been generally employed for the purpose of conducting those analytical studies of kite behavior which we believe to be the most helpful in developing the kite; yet efforts have been made, from time to time, to reach great elevations, either with a single kite or a tandem of two or more. Opportunities with favorable winds are, however, infrequent in Washington. Detailed observations of a few of the more successful high ascensions will give an idea as to what kites of the kind employed may be expected to do. These results are grouped in Table X.

TABLE X.—Details of special ascensions.

Date.	Time.	Angular elevation of kite.	Inclination of wire at reel.	Length of wire out.	Approximate height.	Remarks.
		°	'	Feet.	Feet.	
1896.	A. M. S.	0	0			
Jan. 27	43 00	38	1,300	886	Single diamond kite No. 5; 29 square feet surface; wind favorable at first, but gradually died out; pull from 20 to 24 pounds.
	.....	33 30	17	3,490	2,027
	.....	28 47	.....	4,834	2,328
	.....	28 45	.....	4,894	2,354
	.....	34 15	.....	3,767	2,130
	38 38	2,273	1,419	
Feb. 10	34 7	3,844	2,156	Tandem of No. 9, 16.8 square feet; 200 feet below, No. 12, 12 square feet; 200 feet still lower, No. 5, 29 square feet; fair wind; total surface, 57.8 square feet.
	.....	37 30	.....	3,844	2,331
	.....	39 45	.....	4,696	3,008
	.....	34 10	.....	5,782	3,247
	.....	29 55	.....	7,362	3,622
Mar. 26	52 36	1,000	794	The first reading is the mean of ten made for measuring the incidence of kite, = 21°. These are the first incidence measurements made in the Weather Bureau experiments. Single kite; three-plane rectangular cells, No. 22, 38.4 square feet; wind very favorable; pull from 8 to 16 pounds with 3,975 feet out, and from 20 to 26 pounds with 6,010 feet out, showing considerable increase of velocity with elevation; inclination of wire at reel not recorded, but exceeded 10°.
	.....	36 15	.....	3,975	2,350
	.....	34 00	.....	.....	2,223
	.....	41 32	.....	.....	2,635
	.....	43 10	.....	.....	2,719
	.....	42 35	.....	.....	2,690
	.....	33 30	.....	6,010	3,317
	.....	30 40	.....	.....	3,065
	.....	30 15	.....	.....	3,028
	.....	30 40	.....	.....	3,065
	.....	31 25	.....	.....	3,148
	.....	34 28	.....	.....	3,400
	.....	36 5	.....	.....	3,540
	.....	36 45	.....	.....	3,596
	.....	33 50	.....	.....	3,346
	.....	34 20	.....	.....	3,390
	.....	34 40	.....	.....	3,418
Apr. 30	P. M.					
	1 29 30	53 24	48 54	1,000	803	The first and second observations are the means of ten readings made upon trapezoidal kite No. 28; 43.1 square feet of surface; the incidence was 14.9°; 700 feet from the first a second trapezoid, No. 29, 36.7 square feet, was attached on 150 feet of line; total surface, 79.8 square feet. The wind was not very favorable during these experiments, and it was with difficulty the second kite was started.
	1 36 15	45 42	.....	1,000	715
	2 15 00	61.....	.....	2,000	1,749
	15 30	59.....	.....	.....	1,714
	16 00	57.....	.....	.....	1,677
	16 30	57 30	52.....	.....	1,687
	17 00	58 30	52 30	.....	1,705
	17 30	56.....	50.....	.....	1,658
	18 00	55.....	50.....	.....	1,638
	18 30	55.....	50.....	.....	1,638
	19 00	54 30	49.....	.....	1,628
	19 30	56.....	48.....	.....	1,658
	2 42 30	43 48	30.....	4,000	2,769	
	44 10	46 50	31.....	.....	2,918
	44 45	45 30	32.....	.....	2,853
	45 20	45 59	30.....	.....	2,876
	45 50	45 48	31.....	.....	2,868
	46 35	46 5	30 30	.....	2,880
	.....	46 47	28 30	.....	2,915
	47 10	46 23	26 30	.....	2,896
	49 21	45 21	21.....	.....	2,846
	49 50	43 25	20.....	.....	2,749
	50 48	40 41	21.....	.....	2,608
	51 30	42 23	31 30	.....	2,696
	52 30	45 5	31 30	.....	2,632
	3 00 45	38 30	.....	5,000	3,112
	3 5	39 25	22 30	.....	3,175
	3 45	39 45	23.....	.....	3,197
	4 20	40 5	22.....	.....	3,220
	5 10	40 34	25.....	.....	3,252
	5 48	41 8	26.....	.....	3,290

TABLE X.—Details of Special ascensions.—Continued.

Date.	Time.	Angular elevation of kite.	Inclination of wire at reel.	Length of wire out.	Approximate height.	Remarks.
		°	'	Feet.	Feet.	
1896.	A. m. s.	°	'	Feet.	Feet.	
	6 35	41	57	25	3,342	
	7 10	41	25	30	3,308	
	8 5	39	30	30	3,180	
	8 50	39	9	32	3,157	
	3 17 40	35	40	17	3,326	
	18 45	35	50	16	3,512	
	19 30	36	32	15	3,572	
	20 5	36	59	16	3,610	
	20 45	37	30	16	3,653	
	22 10	38	12	16	3,710	
	22 30	38	30	16	3,735	
May 28	2 34 00	41	35	6,430	4,368	Tandem of two kites. Three-plane kite No. 24, 38.4 square feet surface; two thousand feet lower down the trapezoid, No. 28, was attached, 43.1 square feet. The wind was just about right. The sky was partly overcast with clouds, and towards 3 p. m. it became apparent that a thunderstorm was likely to come up. The electrical discharges from the wire were very sharp, and followed each other in rapid succession, producing sparks an inch or more long. Means were not available at the time for measuring the pull, and the inclination of the wire could not be measured with the device usually employed, owing to the unpleasant effects from the electric discharges.*
	34 30	42	00	"	4,306	
	35 00	42	5	"	4,310	
	36 30	43	30	"	4,413	
	37 50	44	10	"	4,480	
	2 43 20	42	45	7,236	4,912	
	44 30	39	15	"	4,578	
	45	37	00	"	4,355	
	46	37	30	"	4,385	
	46 45	38	55	"	4,546	
	49	43	15	"	4,958	
	49 45	43	42	"	5,000	
	50 30	44	30	"	5,072	
	51 30	45	23	"	5,164	
	52 30	46	36	"	5,258	
	53 30	48	7	9,219	5,387	
	54 30	50	50	"	4,725	
	55 30	52	28	"	4,535	
May 29	3 18	46	45	9,000	6,364	The kite was flown under such circumstances. Unfortunately, however, we can not fly kites with wire having no weight and against which the wind will not press, and, in consequence, our actual kite behaves in a very different manner from that described above. Supposing, as before, that the wind force is the same at all points, high or low, the results we will actually obtain with the kite above employed will be something like these: When but a short length of wire is paid out to the kite, it will take its position upon the same line, <i>RK</i> , as before; that is, for example, at <i>K</i> ₁ . When more wire is unreel, the kite does not continue upward on this line, but, instead, drifts gradually away to leeward and assumes, successively, such positions as at <i>K</i> ₂ , <i>K</i> ₃ , <i>K</i> ₄ , etc., which positions lie on a curve identical with that of the line, but having the ends and sags reversed. An important feature, common to all of the positions the kite may assume, is that the portion of the wire next the kite remains always at exactly the same inclination. The inclination is not only the same for all positions, but is the same as it originally was at <i>RK</i> ₁ . Changes of the wind force and other influences may cause this inclination of the wire to change, but the mere reeling out or in of the wire itself has no effect on the inclination. With a certain amount of wire out, the portion next the reel becomes horizontal, and the limit of altitude is then reached. The kite can lift no more line. All these effects have been brought about under the limitations imposed by the action of gravity and the wind upon the wire. We have mentioned the wind equally with gravity as affecting the wire. It is probable that with moderate wind forces the pressure upon wire, owing to its fineness in proportion to its weight and strength, is a smaller and less important force than gravity.
	3 18 30	46	45	"	6,419	
	3 19	46	45	"	6,474	
	3 19 30	46	45	"	6,535	
	3 20	46	45	"	6,474	
	3 20 30	46	45	"	6,535	
	3 21	46	45	"	6,474	
	3 21 30	46	45	"	6,535	

*The group of observations made with 2,000 feet of wire out represent the height of the base of the gathering clouds within which the kite was frequently obscured. About half past three p. m. a very severe thunderstorm burst upon us, and we were obliged to seek shelter. The kites continued to fly for several minutes during the storm, but finally broke loose. The storm was one of the most violent that has ever been known in Washington, and much damage was done throughout the city to roofs of houses, etc. A lofty steel flagstaff at Fort Myer, near the point at which the kites were flown, was bent over by the force of the wind at an angle of about 45° at the point about 50 feet above the ground, where it was held by guys. The kites were both found the same afternoon at a distance of 15 miles due east of the point from which they were flown. Neither kite had been damaged by the storm, and both are still in good condition.

THE KITE LINE.

Thus far in the study of the behavior of kites and in the analysis of the forces acting thereon we have considered, with few exceptions, only the kite itself. We now wish to study the forces acting upon the wire, with a view to clearly setting forth in what manner and to what extent these forces influence the elevation attainable with a given kite.

If we could employ a wire having no weight, and so fine that the pressure of the wind upon it would be wholly inappreciable, then, as more and more of this wire is paid out to it, the kite would pass outward and upward along the same straight line, such as *RK*, Fig. 72, retaining always the same angular elevation as seen from the reel. Provided the wind continued unchanged in force, there would be no limit to the height to which a kite could be flown under such circumstances. Unfortunately, however, we can not fly kites with wire having no weight and against which the wind will not press, and, in consequence, our actual kite behaves in a very different manner from that described above. Supposing, as before, that the wind force is the same at all points, high or low, the results we will actually obtain with the kite above employed will be something like these: When but a short length of wire is paid out to the kite, it will take its position upon the same line, *RK*, as before; that is, for example, at *K*₁. When more wire is unreel, the kite does not continue upward on this line, but, instead, drifts gradually away to leeward and assumes, successively, such positions as at *K*₂, *K*₃, *K*₄, etc., which positions lie on a curve identical with that of the line, but having the ends and sags reversed. An important feature, common to all of the positions the kite may assume, is that the portion of the wire next the kite remains always at exactly the same inclination. The inclination is not only the same for all positions, but is the same as it originally was at *RK*₁. Changes of the wind force and other influences may cause this inclination of the wire to change, but the mere reeling out or in of the wire itself has no effect on the inclination. With a certain amount of wire out, the portion next the reel becomes horizontal, and the limit of altitude is then reached. The kite can lift no more line. All these effects have been brought about under the limitations imposed by the action of gravity and the wind upon the wire. We have mentioned the wind equally with gravity as affecting the wire. It is probable that with moderate wind forces the pressure upon wire, owing to its fineness in proportion to its weight and strength, is a smaller and less important force than gravity.

By the aid of well-known mathematical formulæ we can determine in the most complete and exact manner all the effects due to the action of gravity on the wire. On the other hand, the effects of the combined action of wind and gravity are of a very complex character, are but little known and understood, and can be mathematically represented only in a most general and imperfect manner. The effect of the wind pressure on the wire will be disregarded for the present and we will proceed to develop the properties of the curve assumed by the kite wire as if it were wholly dependent upon gravity alone. We will indicate afterwards how certain allowances can be made for the wind effect.

PROPERTIES OF THE CATENARY.

The name catenary is applied by mathematicians to the curve assumed by a chain or perfectly flexible inextensible string of uniform weight, when suspended from two points and acted upon by gravity alone. The kite wire is far from being perfectly flexible, but when the curve it assumes is formed on a large radius, as in kite flying, the wire may be regarded as perfectly flexible and the curve a true catenary, except for the wind effects. We may conceive that, owing to the stiffness and springiness of the wire, the curve in its minutest details acquires very small, but relatively long, waves and sinuosities. These, however, are utterly inappreciable and of no importance when steel wire is used. In the case of strings, the wind effect is more important, and, moreover, the extensible properties of the string prevent the actual curve from being a true catenary. We make mention of these disturbing influences, but do not attempt to give them further consideration.

The catenary possesses many very remarkable and interesting properties that have a more or less important bearing upon the art of flying kites. In presenting and treating of these properties we can scarcely avoid the use of certain equations, but we hope the verbal statements of results and conclusions reached by their aid will be interesting to both mathematical and non-mathematical readers alike.

The fundamental equations of the catenary may be written in a variety of forms, depending upon the variables employed. Each equation expresses some interesting property of the curve. Some of the forms most convenient for use are the following:

$$y = \sqrt{s^2 + c^2} - c \quad (1)$$

$$s^2 = y^2 + 2yc \quad (2)$$

$$x = c \text{ nap. log. } \frac{s + \sqrt{s^2 + c^2}}{c} \quad (3)$$

$$\tan. \theta = \frac{s}{c} = \frac{dy}{dx} \quad (4)$$

$$t = w(c + y) \quad (5)$$

In these equations the origin of coordinates is taken at the point where the curve is horizontal; s is the length of the curve measured from the origin, c is a constant, θ is the angle of inclination of the curve with the horizontal at the upper end of a portion of length s , t is the tension at this upper end, and w is the weight per unit length of the material of which the catenary is formed.

In Fig. 73 let $A O B$ represent a catenary. The curve has similar branches on either side of $O Y$, but we are generally concerned with only a portion of the curve on one side. If the wire is just horizontal at the reel, then the position of the reel will be represented by the point O in the diagram. If the wire at the reel is inclined upward, more or less, then the position of the reel will be represented on the diagram by some such point as R , at which point the curve is inclined at the same angle as the wire at the reel.

Tension.—The tension of the wire at the lowest point, that is at O , when the curve is horizontal is less than at any other point. The quantity c in the equation above is given by the

expression $c = \frac{t}{w}$. That is, c is the length of a piece of wire

whose weight equals t , the tension in the curve at the lowest point. Extend the line $Y O$ down to O' , making $O O' = c$, and draw the horizontal line $D D'$. This line is known as the *directrix* of the catenary. We found above that c was the length of a piece of wire whose weight equaled the tension at the lowest point. Any other vertical line, such as c' , drawn from a point p on the catenary to the directrix represents, in like manner, the tension at the point p .

If $t \theta$ and $t' \theta'$ are, respectively, the tensions and inclinations of the curve at any two points, then, from equations (1), (4), and (5), there results,

$$\frac{t}{t'} = \frac{\cos. \theta'}{\cos. \theta} \quad (6)$$

Maximum height.—Let P represent the point at which the kite acts on the wire, and suppose that the reel is at O , the kite will then be at its maximum height, which is represented by the ordinate y . The whole catenary is sustained by the pull of the kite. This pull is exerted in a certain direction, and with a certain intensity. It was pointed out above that with a steady, constant wind force, and the same kite, the direction and intensity of the pull remains fixed and invariable. Let the inclination of the wire next the kite be represented by the angle θ , as indicated in Fig. 73; then, as seen from the reel, the kite will have the angular elevation $P O X = \phi$. If s is the length of the wire up to the kite then the height of the kite will be, from equation (1),

$$h = y = \sqrt{s^2 + c^2} - c$$

Replacing c in this equation by its value in terms of $\tan. \theta$, and reducing, we obtain

$$h = y = \frac{s}{\sin. \theta} (1 - \cos. \theta) \quad (7)$$

This equation tells us that when a kite has taken up all the line it can carry the height may be expressed in terms of the length of the line and the inclination of its topmost portion. If we imagine several kites in the air, some small ones restrained with fine threads and strings, others larger with fine wires, others again still larger with heavy cables, and if we suppose further that all these kites pull their respective lines at the same angle θ , and that when the same length of line is out the bottom end is just horizontal, then equation

(7) tells us that all these kites will be at the same elevation and that the curves of their respective lines will be exactly alike whether the lines are light or heavy. The only difference in the conditions existing in the several lines will be one of tension, which will necessarily be greater in the heavy than in the light lines. These statements are graphically verified by a very simple experiment. Take several chains or other very flexible strings of very different weights per lineal foot, suspend exactly equal lengths of these chains and strings between any two points, the curves assumed will be identical. We learn further from equation (7) that so far as the action of gravity on the kite line is concerned nothing is to be gained or lost by the use of either light or heavy lines. The tension under given conditions will be exactly proportional to the weight of the line employed. Heavy lines will require proportionally larger kites to produce the same effects. This is evident from equation (5)

$$t = w(c + y) = w \left(\frac{s}{\tan. \theta} + h \right) \quad (8)$$

in which for the same values of s , θ , and h the tension is directly proportional to w .

Angular elevation at maximum height.—Returning to the consideration of a single kite at P , Fig. 73, ϕ is the angular elevation of the kite observed at the horizontal point of the curve and when the linear altitude of the kite is a maximum. From trigonometry we have

$$\tan. \phi = \frac{y}{x}$$

Substituting in this equation the value of y in equation (7) and x from equation (3), eliminating c by means of equation (4), and reducing, we get

$$\tan. \phi = \frac{y}{x} = \frac{1 - \cos. \theta}{\cos. \theta \text{ nap. log. } (\sec. \theta + \tan. \theta)} \quad (9)$$

The second member of this very interesting equation contains only the quantity θ . The meaning of this is that when a kite has taken out all the line it can carry, or when the line at the reel is horizontal, the kite's angular elevation will be a minimum, and will depend entirely upon the inclination of the upper part of the line next the kite. If we imagine several kites of different sizes pulling with different forces, but all pulling their respective lines at the same angle, then these kites, when each has lifted all the wire it can carry, will all have the same angular elevation measured from the lowest point of the line. If these lowest points are all brought together at a common point represented, for example, at O , in Fig. 73, the kites will all take up positions one behind the other as at P, P', P'' , etc., on the straight line, $O P$.

Isoclinals.—It results from the above that if we draw a large series of catenaries, each corresponding to a given value of c , upon the same coordinate axes as in Fig. 74, then a line like $O C$, radiating from the origin O , will intersect every conceivable catenary at the same angle, and the tangents to the curves at the points of intersection will form a system of parallel lines. Any other radial line, as $O C'$, will intersect at a new angle and form a different set of parallel tangents. The radial lines under these circumstances may be called *isoclinals*, and designated $C_\theta, C_{\theta'}$, etc., corresponding to the angles of inclination of the curve at the points of intersection. All conceivable catenaries formed upon the coordinate axes $O X$ and $O Y$ must, in the diagram, be comprised within the space above the axis $O X$ and no two of the catenaries can intersect. Fig. 75 is a diagram embracing a comprehensive system of lines, catenaries, etc., formed upon the principles stated above. These principles have important applications with respect to the behavior of kites.

The angle of inclination of that part of the wire that is next to the kite, or the bridle, tends, as we have seen, to remain comparatively constant, it changes to some small extent with changes in the force and vertical component of the wind, and the angle differs more or less in different kites. Other things remaining the same, however, the real problem in designing kites that shall attain great elevations is to cause this angle to be as great as possible. We see now the reason for this. The position of a kite which pulls the wire at an angle of 50° to the horizontal must, for the maximum height, be represented by a point on the line OC_{50} of Fig. 75. The corresponding angular elevation ϕ , as seen from the reel and as given by equation (9), is only $\phi = 28^\circ 48'$, and it makes no difference what kind of line is employed or how much is paid out, the position of the kite pulling at an angle of 50° must, when it attains its maximum elevation, be represented by a point on the isoclinal C_{50} . Similarly, a kite pulling at 60° attains its maximum elevation at an apparent angular altitude of $\phi = 37^\circ 13'$, and in the diagram, Fig. 75, its position is represented by some point on the isoclinal C_{60} .

Isoclinals for practical cases.—Having thus, from the properties of the catenary, learned the effects resulting from pulling the upper end of a kite line in different directions, let us refer to actual observations on kites and ascertain at what angles the wire is actually pulled in practical cases. Table IX contains the results of numerous observations upon kites and the angles we now seek are given in one column under the heading θ = inclination of wire at kite. The smallest θ angle recorded is 48.8° and the largest 64.2° and it happens that both results were obtained with the same kite, namely, the three plane kite shown in Fig. 56.¹ The difference between these two values is partly due to differences of wind force, but also to alterations made in the bridle on different occasions. Our experience with this class of kites shows that the angle between the horizontal and the wire next the kite rarely exceeds 60° , except with kites of the best form and under very favorable conditions of wind. A greater inclination than 60° may in some cases be obtained with kites of light weight by adjusting the bridle so that the angle of incidence is small. In that case, however, the wind pressure is lessened and the gain that arises from a steeper angle of pull is more than counterbalanced, perhaps, by the diminution in the amount of the pull. The selection of the most advantageous angle of incidence is an interesting point which will be considered later.

Equitensals.—Referring again to Fig. 75 we recall that we found that, when at their maximum height, the positions of all kites pulling at 50° may be represented by points on the isoclinal C_{50} ; similarly those of kites pulling at 60° by points upon the isoclinal C_{60} . Now, suppose it were possible to cause a kite to continue to pull with the same constant force, while the direction of the pull at the kite is changed, it will be interesting to inquire what effect a change in the angle of pull can produce upon the maximum possible elevation of a kite. From a mathematical standpoint the answer to this question consists in drawing a line in Fig. 75 of such a character that the tensions on all the catenaries at the points of intersection with the new line will be the same. Such intersecting lines may be called *equitensals*, since they cut the catenaries at points of equal tenseness or pull on the line. We may find the equation of such a line as follows: From equation (8) we have for the tension at a point whose elevation is h and where the curve is inclined at an angle θ ,

$$t = w \left(\frac{s}{\tan. \theta} + h \right)$$

from which

$$\frac{s}{\sin. \theta} = \frac{t - hw}{w \cos. \theta}$$

Substituting this expression in equation (7) and solving for h we have

$$h = \frac{t(1 - \cos. \theta)}{w} \quad (10)$$

which is the equation sought. This equation may be stated in another form, in terms of s , by deriving it in a similar manner from equations (7) and (8) by eliminating h . The result is

$$s = \frac{t}{w} \sin. \theta \quad (11)$$

Equation (10) gives us the maximum height attainable by a given kite pulling at an angle θ with tension t , the wire weighing w pounds per unit length. Equation (11) gives the length of wire required by the kite to attain this position.

In Fig. 75 TT' is an *equitensal* passing through the point P . The points at which this line crosses the isoclinals C_{50} , C_{60} , C_{65} , etc., are the positions that would be taken by kites that are at their maximum altitudes and all pulling equally hard, but at angles of 50° , 60° , and 65° respectively. In constructing any *equitensal*, such as TT' , we observe that if h_{50} equals the height at which the *equitensal* crosses the isoclinal of 50° , then the height at which it crosses the isoclinal of 60° will be

$$h_{60} = h_{50} \frac{1 - \cos. 60^\circ}{1 - \cos. 50^\circ} = 1.400h_{50}$$

Drawing a horizontal line on the diagram at a height $= 1.4h_{50}$ above the line OX , the point at which it intersects the isoclinal C_{60} is a point on the desired *equitensal*. Other points may be located in a similar manner.

Furthermore, equation (11) shows that if s_{50} is the maximum length of the curved line of wire that a kite pulling with a certain force can sustain when the angle of pull at the kite is 50° , then by pulling with the same force at an angle of 60° , it will carry up a length of wire given by the expression

$$s_{60} = s_{50} \frac{\sin. 60^\circ}{\sin. 50^\circ} = 1.130s_{50}$$

These results may be presented in another and perhaps more striking manner. Suppose a kite pulling with a certain force at an angle of 50° is able to attain a maximum elevation of 1,000 feet. If now, by any means, we can cause the kite to pull with the same force at an angle of 60° instead, it will attain an elevation of 1,400 feet, being a direct gain of 400 feet in 1,000 for an increase of 10° in the angle. The length of wire required in the first case will be 2,145 feet, and in the second case 2,425 feet. Although 400 feet have been gained in elevation by the change, yet only 280 feet more of wire have been required. With the kind of wire employed in the Weather Bureau work, weighing 2.155 pounds per 1,000 feet, the tension required at the kite in both cases will be 6.03 pounds. The weight of the additional 280 feet of wire is 0.603 pounds. The kite then, without pulling any harder, flies 400 feet higher and carries 0.603 pounds more wire. This gain in height and carrying power is wholly due to the improvement in the angle of pull in the kite. It is important to notice here that this increase in the angle of pull must not be brought about, as it might be, by lessening the angle of incidence of the kite, because in that case the pull of the kite would also be lessened, and our comparison has been drawn on the supposition that the pull has remained constant. There is a way, however, in practical cases by which the desired improvement in the *direction* of the pull can be brought about without sensibly diminishing the *intensity* of the pull. If the kite pulling at 50° is badly defective in respect to edge pressures, waviness and fluttering, eddy effects, etc., then by

¹ Fig. 56 will be found in the WEATHER REVIEW for May.

eliminating these defects the angle of pull will be increased with only a very slight diminution of pull. From actual measurements upon Weather Bureau kites, gains of as much as 10° in the angle of pull are sometimes possible in practical cases with no loss in intensity of pull.

Incidence for maximum altitude.—We have noticed before that the advantage which may be gained by lessening the angle of incidence of the kite, and which, other things remaining the same, would tend to make the direction of pull steeper, may be more than counterbalanced by the diminution in the intensity of the pull, which necessarily accompanies a diminution of the angle of incidence. Furthermore, there is another wholly independent and very important factor bearing directly upon this question, namely, the efficiency as affected by changes in the pressure of the wind. It was shown on page 241 that when the wind pressures upon kites became relatively small, as may be the case with relatively small angles of incidence, the efficiency angle, owing to the pronounced effect of the weight of the kite, also became small. We may state this in other words, as follows: Lessening the angle of incidence not only always lessens the pull but it may also lessen the angle at which the kite pulls the string, owing to the detrimental effect of the weight of the kite under feeble wind forces. If we set the kite at too great an angle of incidence it will fail to reach a great elevation, because in spite of the strong pull it may exert, the direction of this pull is at too unfavorable an angle for the best effect. On the other hand, too small an angle of incidence, owing to the falling off in efficiency, likewise fails to bring about the most satisfactory result. It is apparent, however, that between these extremes is a condition, a particular angle of incidence, leading to the maximum linear elevation. On account of the change which may take place in the efficient action of the kite when the incidence of the kite is changed, and arising more particularly in light winds it is probable that the *incidence for maximum effect* should be determined independently and separately for each kite. Data is not available by which this can be done at present, and it will be quite as instructive, in the present case, to analyze the problem in a general way. This will give an idea as to the approximately best angle of incidence.

Ideal and actual kite.—There are two conditions for which we may seek the solution of this problem. We may consider only the special case of the ideal kite, with a constant efficiency of 100 per cent, or we may ascertain the best incidence of actual kites of several stated efficiencies. The complete solution would require that we suppose the efficiency to vary as a function of the incidence. It is in respect to this condition that data is as yet wanting. We will, therefore, first solve the equations for the ideal conditions, and afterward consider the actual kite, with several different efficiencies, in order to give a range between which most practical cases will fall.

Best incidence—ideal case.—If i is the angle of incidence of the kite, then, in the ideal case, the direction of pull will be,

$$\theta = (90^\circ - i).$$

Now, the force with which the wind presses upon flat surfaces at different angles of incidence is given with a close degree of approximation by Duchemin's formula, as follows:

$$P = P_0 \frac{2 \sin. i}{1 + \sin.^2 i} \quad (12)$$

In this expression P represents the proportional pressure upon the inclined surfaces of the kite and P_0 the corresponding pressure of the wind upon the same surfaces exposed normally to the wind direction. The formula is strictly applicable to flat surfaces only. It is applied to kites in the manner that follows because a better formula is not known.

We desire to know, at least approximately, which is the best angle of incidence in a given case, and this we believe Duchemin's formula will give.

The pull of an actual kite—that is, the tension in the wire at its upper end—is represented by the diagonal of a parallelogram, of which P from the above equation is one side and W , the weight of the kite, is the adjacent side. The included angle is $180^\circ - i$. In the ideal kite we assume that the weight is inappreciable, compared with the wind force on the kite, and, as a direct consequence of this assumption, the diagonal of the above mentioned parallelogram coincides with the side P ; in other words, in the ideal kite the pull is equal to the pressure of the wind; hence we may write for the tension in the wire at the upper end,

$$t = P = P_0 \frac{2 \sin. i}{1 + \sin.^2 i}$$

From this equation and (10), first replacing θ in the latter by its value, $\theta = (90^\circ - i)$, we have:

$$h = \frac{2P_0 \sin. i - \sin.^2 i}{w} \quad (13)$$

This equation gives in terms of the angle of incidence the height attainable by a given ideal flat kite when it has taken out all the line it can sustain. To find the incidence which will give the maximum possible elevation, we need only to determine the value of i from the differential coefficient of equation (13) when that coefficient is placed equal to zero. That is,

$$\frac{dh}{di} = \frac{2P_0 \cos. i}{w(1 + \sin.^2 i)^2} [1 - \sin.^2 i - 2 \sin. i] = 0 \quad (14)$$

whence

$$\sin.^2 i + 2 \sin. i = 1. \quad (15)$$

That is,

$$\sin. i = \pm \sqrt{2} - 1 = +0.4142 \text{ or } -2.4142$$

and

$$i = 24^\circ 28'.$$

The angle of incidence with which the ideal flat surface kite can attain the highest elevation is therefore $24^\circ 28'$, and the corresponding inclination of the wire at the kite is $65^\circ 32'$. The angular elevation of the kite from the reel when the wire is horizontal will be, from equation (9), $\phi = 42^\circ 47'$.

Best incidence for actual kite.—In the case of the actual kite the efficiency will necessarily always be less than 100 per cent, which is practically equivalent to saying that in the actual kite the angle between the wire and the kite will always be less than 90° . This angle of the string is affected by: (1) the wind pressure upon the edges of the kite, waviness, fluttering, eddies, etc., which deflect the action line of the total wind pressure upon the kite away from normal, (2) the weight of the kite must be overcome, and to do this the direction of pull must be deflected away from the direction of the wind pressure. Both these effects (1) and (2) act in the same manner; that is, if g represents the angular deflection due to gravity or the weight of the kite, and e that due to edge pressures, then the direction of pull will be deflected away from the normal to the kite surfaces by an angular amount, represented by $(e + g)$. The relations of the angles in question are shown in Fig. 76. If P represents the pressure of the wind normal to the kite surfaces, then the total wind pressures OQ will be $P = P \sec. e$. Furthermore, in the triangle of forces OQR , from trigonometry, the side $OR =$ pull of kite, will be given by the expression,

$$t = \sqrt{P^2 \sec.^2 e + W^2 - 2PW \sec. e \cos. (i + e)} \quad (16)$$

The angle e is not a known quantity; it is a small angle which is, it seems, practically constant in a given kite, but

may possibly vary with the wind force. This angle, in certain kites has been determined by means of the diagram of forces which is described on p. 243. The angle in the best cellular kites has been found to be under 3° , whereas with inferior kites the value has slightly exceeded 10° . The term $\sec. e$ is, therefore, on account of the small value of e , a quantity which we may assume to be constant without introducing any important error.

In regard to the term $\cos. (i + e)$ it may be said that i , the best incidence for the actual kite must necessarily be smaller than that for the ideal flat surface kite, which we have found to be $24^\circ 28'$. The reason for this is that the effects due to edge pressures, waviness, eddies, etc., tend to depress the kite by forcing it to leeward away from the zenith. To offset this it is necessary to set the kite at a smaller incidence which tends to make it approach the zenith point. We may therefore expect to find the best incidence for the actual kite with flat surfaces smaller than 24° . Since e , as we have seen for the better class of cellular kites observed, is less than 3° , we may assume that $i + e$ will not exceed 25° in actual kites. Moreover the term can not change its value more than a few degrees in extreme cases, which fact together with the general unimportance of the term in any case renders refinement unnecessary and we will therefore assume that this term has the constant value,

$$\cos. (i + e) = a$$

In work with actual kites we can not profitably attain high elevations unless the wind force upon the kite is considerably greater than the weight of the kite. Under ordinarily favorable condition the wind force P will be from 5 to 7 times the weight of the kite and will frequently be still greater. As we seek more particularly to discover the best incidence under conditions of favorable winds we will assume that the weight of the kite in equation (16) is expressed in terms of P , thus, $W = bP$, in which b is a small fraction rarely as great as 0.2 and often less than 0.1.

According to the several assumptions we have made above equation (16) becomes,

$$\text{Pull} = t = P \sqrt{1 + b^2} - 2ab = kP$$

and adopting Duchemin's formula, equation (12), as applicable to cellular kites with flat surfaces, we get,

$$t = kP = kP \frac{2 \sin. i}{1 + \sin.^2 i} \quad (17)$$

In reducing the expression (16) to this form we virtually assume that the tension on the wire next the kite does not undergo any variations with changes of incidence except such as are wholly due to changes in the wind force. This is not strictly the case, for there is a slight variation due to the effects of the weight of the kite and these are fully included in (16). The amount of these variations, however, in the extreme cases will barely attain to 1% of the pressure itself, and we believe that by neglecting them, as we shall do, no serious error will result in the values deduced for the best angle of incidence.

From Fig. 76 we see that

$$\theta = 90^\circ - (e + g) - i.$$

$90^\circ - (e + g)$, it will be noted, is the angle of inclination of the wire to the kite and is a known angle when the efficiency of the kite is known. We have heretofore called this angle the efficiency angle (page 239). Knowing the percentage efficiency, E , of a kite, the efficiency angle, D , is given by the relation,

$$D = 90 \times E$$

and for the inclination of the wire at the kite we may write

$$\theta = D - i$$

with the values of t and θ , given above, and equation (10), we obtain the following equation for the maximum elevation that can be attained by actual flat surface kites depending upon the pull and the angle of incidence; (13) is the corresponding equation for ideal kites,

$$h = \frac{2kP_e (\sin. i - A \cos. i \sin. i - B \sin.^2 i)}{w (1 + \sin.^2 i)} \quad (18)$$

In this equation $A = \cos. D$ and $B = \sin. D$ are sensibly constant for any given kite under conditions of wind force favorable for gaining high elevations.

When the efficiency is 100% $D = 90^\circ$ and $k = 1$. Equation (18) then reduces to (13) for the ideal kite as should be the case.

Differentiating (18) and reducing, we have,

$$\frac{dh}{di} = \frac{2kP_e}{w (1 + \sin.^2 i)^2} \left[(\cos. i - A) \cos.^2 i + 2 \sin. i (A \sin. i - B \cos. i) \right] \quad (19)$$

which is quite analogous to the similar equation (14) for ideal kites. Placing the second member equal to zero for a maximum, we obtain a form convenient for computation, as follows:

$$\cos. i = A \left[1 - 2 (\tan.^2 i - \frac{B}{A} \tan. i) \right] \quad (20)$$

B and A , it will be remembered, depend upon the efficiency. When this is 100 per cent, equation (20) reduces to,

$$\sin. i = \pm \sqrt{2} - 1,$$

the same as already found for the ideal kite.

By means of equation (20) the best angle of incidence for kites of several different degrees of efficiency, ranging from 70 to 95 per cent, have been computed by methods of approximation, and are given in Table XI, with other useful information. Efficiencies as low as 70 per cent ought not to obtain with good kites, except, perhaps, in very light winds, in which case ascensions to considerable elevations with such kites are not practicable. On the other hand, an efficiency of 95 per cent is not by any means unattainable when the wind velocity is favorable—that is, 15 miles per hour or more.

TABLE XI.—Best angles of incidence for flat-surface kites.

	Efficiency.						
	70%	75%	80%	85%	90%	95%	100%
Efficiency angle... D	$63^\circ 00'$	$67^\circ 30'$	$72^\circ 00'$	$76^\circ 30'$	$81^\circ 00'$	$85^\circ 30'$	$90^\circ 00'$
Best incidence... i	$18^\circ 30'$	$19^\circ 33'$	$20^\circ 36'$	$21^\circ 39'$	$22^\circ 41'$	$23^\circ 41'$	$24^\circ 28'$
Inclination... θ	$44^\circ 30'$	$47^\circ 57'$	$51^\circ 24'$	$54^\circ 54'$	$58^\circ 26'$	$61^\circ 59'$	$65^\circ 32'$
Elevation... h	$24^\circ 49'$	$27^\circ 17'$	$29^\circ 53'$	$32^\circ 42'$	$35^\circ 46'$	$38^\circ 07'$	$42^\circ 47'$
Altitude, feet... h	1,000	1,302	1,434	1,666	1,928	2,207	2,504
Pull, pounds... t	7.5	7.8	8.2	8.4	8.7	9.0	9.2
Length of wire... s	2,444	2,708	2,959	3,207	3,447	3,674	3,890
Ratio... $h + s$	0.410	0.444	0.481	0.518	0.559	0.602	0.645

In addition to the best angles of incidence for actual kites of several efficiencies, Table XI gives the maximum heights attainable, computed from equation (18), upon a uniform basis of such conditions as would be required by the kite of 70 per cent efficiency to attain an elevation of 1,000 feet; that is, if the efficiency of this same kite could be increased from 70 per cent to 90 per cent, for example, and with no change whatever in its surface, weight, or other features, it would then, with exactly the same wind, be capable of attaining nearly double the altitude, namely, 1,928 feet. The constant required in equation (18) for these computations is obtained by making $h = 1,000$ when $i = 18^\circ 30'$, and solving for $2kP_e \div w = 12,090$. The assumption that k is constant, as explained above, will not affect the results to an important extent. The pull, t , at the kite and the length of wire, s , may be found most easily from equations (10) and (11),

respectively, in which w is the weight per foot of the steel wire employed at the Weather Bureau, viz, 0.002155 pounds.

A kite showing an efficiency of 85 per cent will, in most cases, be regarded as a very good kite, although still higher efficiencies up to 95 per cent are probably attainable. The altitude attained by an 85 per cent kite is less than that of the 95 per cent kite by 541 feet on a moderate elevation of 1,666 feet. For an ascension of 1 mile the 85 per cent kite would be deficient by over 1,700 feet, that is, the 95 per cent kite under precisely the same circumstances would ascend 1,700 feet more than the mile.

It is plain that where such large gains as this are possible, it devolves upon every one who aims to get the highest elevations to fully inform himself as to the real merit of his kites and see to it that they are bridled and flown under the best adjustments.

The results which have been brought out in the foregoing discussions concerning the best incidence depend upon Duchemin's law of variations of pressure with incidence, and apply only to kites with flat as distinguished from arched surfaces. The best incidence for arched surfaces is undoubtedly smaller than for flat surfaces. We have also disregarded the effect of the wind upon the wire, which while small, is still of some importance, and as its effect is to drift the kite to a position further away from the zenith than would otherwise be attained, the best incidence when the wind effect is included will be smaller than given in Table XI.

Maximum sag and slack of wire.—We have called the angles between the curve and its chord the sag of the wire, as for example the angles S and S' , Fig. 67. We will similarly use the term *slack* to designate the difference between the length of the chord and the length of the curve itself.

When the wire is horizontal at the reel the angle of sag at that point is then the same as the angular elevation of the kite, that is $S' = \phi$, the sag at the kite is similarly, $S = \theta - \phi$. Dealing with portions of the catenary on one side only of the Y axis, S' is the maximum sag possible.

If r is the air-line distance between the reel and the kite when the wire is horizontal, then,

$$r = \frac{h}{\sin. \phi}$$

combining this equation with (7) we get,

$$r = \frac{s(1 - \cos. \theta)}{\sin. \theta \sin. \phi}$$

and the slack will be,

$$s - r = s \left(1 - \frac{1 - \cos. \theta}{\sin. \theta \sin. \phi} \right)$$

We will consider hereafter the sag and slack for conditions less than the maximum.

Partial ascensions.—In the discussion of the properties of the catenary we have thus far treated only of the behavior of kites when they have ascended to their utmost limit and sustain all the wire they can carry. All those conditions which tend to produce the best results when the wire is horizontal at the reel are equally beneficial in the case of partial ascensions where the kite carries up only part of the wire it can sustain, and the portion at the reel is inclined to the horizontal at a slight angle. Partial ascensions are the usual cases in practice. When the wire at the reel becomes horizontal the frequent diminutions of wind force allow it to temporarily sag to the ground or to interfere with trees, buildings, etc., and in general, therefore, we must provide some margin within which the usual variations of pull may occur without permitting the wire to sag to an objectionable extent. Furthermore we see from Fig. 72 that, since the path described by the kite in attaining its maximum elevation is the inverted

catenary, the last portion of the ascent is very slight, and but little is gained in paying out wire to the last extremity.

The constancy of the inclination of the upper portion of the wire in the successive positions assumed by a kite passing upward from the reel to a maximum elevation, as shown in Fig. 72, was pointed out on page 246. The several curves of the wire are all portions of one and the same catenary, that is, portions of the curve RK_1 . When but a short length of wire is out, its curve is the portion of the catenary from K_1 down to such a point as R_1 . With greater and greater lengths of wire out it is as if the reel were moved backward and downward along the catenary passing through positions such as R, R_1 , etc., while the kite has remained stationary. When we know the angle of inclination of the wire at the reel in a given case we can locate its position on the catenary. The diagram in Fig. 75 represents all conceivable catenaries and may therefore be employed to represent graphically any partial ascension. For example, if the wire at the reel is inclined at an angle, $\theta' = 10^\circ$, then the position of the reel is represented in the diagram by some point on the isoclinal C_{10} . The particular point on the isoclinal will depend upon the tension, t' , at the reel. If this is known, then the position of the reel is located at the point of intersection of the isoclinal C_{10} and the equitensal t' . The catenary passing through the point of intersection is the particular one representing the kite wire in the given case and the position of the kite at the upper end may be located in several ways.

If θ , the inclination of the wire at the kite is, for example, $\theta = 60^\circ$, then the position of the kite will be represented by the point of intersection of the particular catenary already found with the isoclinal C_{60} . If ϕ' is the angular elevation of the kite from the reel we may lay off on the diagram a line making the angle ϕ' with OX and passing through the point representing the position of the reel. The upper intersection of this line, with the particular catenary representing the kite line, gives the position of the kite. There is still another and more general graphical way of locating the kite on the diagram. It is possible to draw a system of lines on the diagram resembling the equitensals and crossing the catenaries, but cutting off equal arcs of the curves measured from the origin. The equation for these *equiarcs* is obtained simply by making θ and h the variables in equation (7) thus:

$$h = \frac{s}{\sin. \theta} (1 - \cos. \theta)$$

Lines of this character are designated on the diagram by the letters L_1, L_2 , etc. The subscripts indicate the length of arc cut off from the origin in units of 1,000 feet. Having located on the diagram the position of the reel, in the case of a partial ascension, the equiarcal passing through that point gives the length on the catenary from the reel to the origin. Knowing, in addition to this, the length of wire out, the sum of the two determines the equiarcal for the kite. The point of intersection of this with the particular catenary passing through the reel gives the desired position of the kite.

The linear elevation of the kite is the vertical distance on the scale of the diagram between the positions found for the reel and the kite.

By such methods as we have thus described a diagram of the kind shown in Fig. 75 may be employed as a graphic chart completely representative of any ascension that may be made with a single kite. Numerical tables for deducing elevations, etc., will probably be preferable in many cases but the chart shows the results graphically and has been discussed at length more particularly because of the several interesting properties of the catenary involved in its use.

General equations for partial ascensions.—Fig. 77 represents a partial ascension in which the reel is at R and the kite at

K , with the origin of coordinates at O . Letters designating the coordinates of the catenary at the point representing the reel are distinguished by a superscript, ($'$). The linear elevation of the kite is $h = y - y'$ and the length of wire out is $l = s - s'$.

If t' is the tension of the wire at the reel then from equation (10) we have,

$$y' = \frac{t'}{w} (1 - \cos. \theta')$$

Eliminating c from equation (1) by its value in terms of t' and θ' and replacing s by its value $s = l + \frac{t'}{w} \sin. \theta'$ we obtain,

$$y = \sqrt{l^2 + \frac{2lt'}{w} \sin. \theta' + \left(\frac{t'}{w}\right)^2} - \frac{t'}{w} \cos. \theta' \quad (21)$$

Whence,

$$h = y - y' = \sqrt{l^2 + \frac{2lt'}{w} \sin. \theta' + \left(\frac{t'}{w}\right)^2} - \frac{t'}{w} = r \sin. \phi' \quad (22)$$

From this equation we learn that when the length of wire out is known together with the tension and inclination at the reel, the height of the kite is given, even though it is concealed from view, as by clouds, darkness, its remote distance, etc. This results from a general property of the catenary and the equation is equally applicable to the case of either partial or complete ascensions. Owing to great momentary variations that take place in the tension of the wire, calculations of elevations depending upon the tension at the reel will not, as a rule, be as accurate as those deduced by other methods, but equation (22) will undoubtedly prove useful in cases where other methods of ascertaining elevation are not available.

In passing, it may be remarked that the elevation of an invisible kite deduced by equation (22) will be more accurate, as the sag in the wire is greater.

If θ and t are the inclination and tension of the wire at the kite, we may write,

$$y = \frac{t}{w} (1 - \cos. \theta), \text{ and } y' = \frac{t'}{w} (1 - \cos. \theta')$$

whence, by equation (6), we get,

$$h = y - y' = \frac{t}{w} \left(1 - \frac{\cos. \theta}{\cos. \theta'}\right) = r \sin. \phi' \quad (23)$$

an equation which we shall have occasion to use hereafter.

Observed angular elevation.—Instead of measuring the tension in the wire at the reel in a given case, we may observe the angular elevation, ϕ' , of the kite from the reel, and if we can determine the relation between ϕ' and t' , the latter may be eliminated from equation (22). From trigonometry we have

$$\tan. \phi' = \frac{h}{x - x'}$$

The value of x' in terms of t' and θ' , deduced from equations (3), (4), and (11), is,

$$x' = \frac{t'}{w} \cos. \theta' \text{ nap. log. } (\sec. \theta' + \tan. \theta') \quad (24)$$

Similarly the value of x is,

$$x = \frac{t}{w} \cos. \theta' \text{ nap. log. } \frac{l + \frac{t'}{w} \sin. \theta' + \sqrt{l^2 + \frac{2lt'}{w} \sin. \theta' + \left(\frac{t'}{w}\right)^2}}{\frac{t'}{w} \cos. \theta'}$$

From these values of x and x' and the value of h given in (22), we obtain a very complex transcendental equation, representing the relation between the angular elevation at

the reel and other quantities that are known. The value of t' corresponding to a given value of ϕ' can be deduced from this equation only by methods of approximation. It will not, therefore, be practicable to eliminate t' from equation (22) in the manner contemplated, but we can, by tabulating a limited number of values of the several quantities, deduce the percentage of slack in the wire corresponding to such conditions as are likely to occur in practice, and thus provide a method for accurately computing the height of kites, in partial ascensions, that does not depend upon the tension of the wire.

Slack in the wire in partial ascensions.—Let r be the length of the chord of the catenary from the reel to the kite, then,

$$r = \frac{h}{\sin. \phi'} \quad (25)$$

$$\text{slack} = l - r \text{ and percentage of slack} = 1 - \frac{r}{l}$$

The ratio of any chord of a catenary to the corresponding arc is given by the equation

$$\frac{r}{l} = \frac{\cos. \theta' - \cos. \theta}{\sin. \phi' \sin. (\theta - \theta')} \quad (26)$$

which may be obtained from equation (23) by eliminating $\frac{t}{w}$ in terms of l .

The relation between ϕ' , θ , and θ' is obtained by forming an equation for x similar to (24) for x' , whence, with the value of h in (23), there results,

$$\tan. \phi' = \frac{h}{x - x'} = \frac{\sec. \theta - \sec. \theta'}{\text{nap. log. } \left[\frac{\sec. \theta + \tan. \theta}{\sec. \theta' + \tan. \theta'} \right]} \quad (27)$$

Table XII contains a series of values of ϕ' deduced from equation (27) corresponding to such assumed values of θ and θ' as may occur in practice. With each value of ϕ' is also tabulated the corresponding percentage of slack computed by means of equation (26). The results are rigorous representations of the properties of the catenary, and even though the wind effect has been omitted, the relations of the quantities concerned are such that the wind effect on the wire can not modify the percentage of slack, corresponding to given values of ϕ' and θ' , except by a quantity of secondary magnitude.

TABLE XII.—Angular elevation and percentages of slack.

	θ' = Inclination of wire at reel.						
	0°.	10°.	20°.	30°.	40°.	50°.	60°.
$\theta = 50^\circ$ { Slack, %	3.22	2.03	1.11	0.51	0.13	.....	.....
ϕ'	28.5°	32.9°	36.9°	41.0°	45.3°	.....	.....
$\theta = 55^\circ$ { Slack, %	3.87	2.55	1.53	0.78	0.29	0.08	.....
ϕ'	32.8°	36.6°	40.4°	44.2°	48.2°	52.6°	.....
$\theta = 60^\circ$ { Slack, %	4.53	3.10	1.97	1.11	0.50	0.13	.....
ϕ'	37.2°	40.8°	44.3°	47.8°	51.4°	55.4°	.....
$\theta = 65^\circ$ { Slack, %	5.17	3.65	2.43	1.48	0.76	0.28	0.08
ϕ'	42.2°	45.4°	48.5°	51.7°	55.0°	58.5°	62.6°

TABLE XIII.—Ratio of sag = $S \div S'$.

	$S' = \phi' - \theta'$ = sag at reel.							
	2°	4°	6°	8°	10°	12°	14°	20°
$\theta = 50^\circ$	0.950	0.910	0.878	0.852	0.828	0.810	0.793	0.758
$\theta = 55^\circ$	0.942	0.894	0.856	0.826	0.800	0.779	0.760	0.718
$\theta = 60^\circ$	0.929	0.876	0.834	0.800	0.770	0.746	0.724	0.671
$\theta = 65^\circ$	0.918	0.854	0.804	0.766	0.731	0.705	0.681	0.627

The practical use made of Table XII is as follows: With ϕ' and l we compute the approximate elevation of the kite from the equation, $h' = l \sin. \phi'$; with ϕ' and θ' we take from Table XII the corresponding percentage of slack; deducting from h' this same percentage of itself there results the actual elevation.

The ratios of the angles of sag, given in Table XIII, will be understood from what follows:

Angles of sag in partial ascensions.—In making efficiency tests we measure the angle of sag, S' , at the reel, and desire to know the corresponding sag, S , at the kite. The ratio $S \div S'$ of these angles is nearly constant when S' is small, and it varies but little with different values of θ' . In computing these ratios we have used the relations $S' = \phi' - \theta'$ and $S = \theta - \phi'$, which are apparent from Fig. 77, and the values of ϕ' deduced from equation (27).

Altitude as dependent upon pull.—Kites of different size pull with different forces. The maximum altitude a kite pulling with a given force t , at an inclination θ can attain is given by equation (10) thus,

$$h = t \frac{(1 - \cos. \theta)}{w} \quad (10)$$

A kite that pulls twice as hard as another can, we see, attain twice the altitude. Moreover equation (7) shows that exactly twice the length of wire will be required. If instead of one large kite two smaller ones, each pulling half as hard but at the same angle, were made to pull, without interference, at the end of the line, it is plain that the combined action of the two kites would necessarily be equivalent to that of the large one in every respect. Suppose, however, the two kites were formed into a tandem in the usual fashion; we wish to know whether the top kite can then attain a greater, an equal, or a less elevation than that reached by the single equivalent kite.

Kites in tandem.—Some mention was made on page 121¹ of the greater steadiness of pull resulting from the use of two or more kites in tandem. This is an important matter in itself but does not directly concern us here as our analysis of the properties of the catenary proceeds upon the assumption that the tension on the wire is, in all cases, sufficiently steady to keep the resulting curve in a condition of complete static equilibrium. We assume further in our discussion of the distribution of kites in a tandem that all are subjected to the same wind force.

Two considerations arise in flying kites in tandem, namely, (1) having given a certain pull, acting in a certain direction, how shall this be employed to gain the maximum elevation? Shall the pull be concentrated and applied at the end of the kite line, or shall it be subdivided and distributed, and if so, how? (2) Having given a wire or line capable of sustaining a certain maximum safe-working tension, how shall it be employed with actual kites to attain the maximum elevation? We shall find that the same general equations will enable us to answer both these questions.

General equations for tandems.—Our equations will be sufficiently general if we assume that the different kites which go to make up the tandem are exactly equal in all respects, hence t and θ will represent the intensity and inclination of the pull of any of the kites.

Fig. 78 represents the forces acting at the point at which a second kite is attached to the line from the topmost or so-called pilot kite. Using a notation similar to that already employed, θ' and t' are, respectively, the inclination and pull of the portion of wire just above the point at which the second kite is attached. (θ' and t' result from the action of the pilot kite.) θ_2 and t_2 are respectively the inclination and pull of the portion of wire just below the point at which

the second kite is attached; they represent the combined power of both kites. Constructing the parallelogram of forces between the tensions involved we obtain from trigonometrical relations,

$$t_2 = \sqrt{t^2 + t'^2 + 2tt' \cos. (\theta - \theta')} \quad (28)$$

but,

$$t' = t \frac{\cos. \theta}{\cos. \theta'}$$

whence,

$$t_2 = t \sqrt{1 + \frac{\cos.^2 \theta}{\cos.^2 \theta'} + 2 \frac{\cos. \theta}{\cos. \theta'} \cos. (\theta - \theta')} \quad (29)$$

an equation which represents the resultant or combined pull of the two kites. The direction, θ_2 , in which this pull is exerted, is obtained as follows: In the triangle of forces t , t' , and t_2 , let a be the angle included between the sides t' and t_2 , then,

$$\sin. a = \frac{t}{t_2} \sin. (\theta - \theta')$$

From the diagram it is seen that,

$$\theta_2 = \theta' + a$$

In assuming that the second kite pulls at an angle θ and tension t at the point where it is attached to the main line we neglect, as we may without sensible error, the influence of the short connecting wire between the kite and main line.

The combined action of the two kites is, by the above equations, completely expressed in terms of the power of one kite. By a precisely similar process we may determine the effect of adding a third, a fourth, or any number of subordinate kites in tandem. As our object is to discover the best arrangement of kites in tandem it will suffice if we make comparisons on the basis of two kites only, since if there is a gain or a loss with two kites, a similar result will obtain with three or more.

Having attached a second kite to the line, let wire be unreel until the portion next the reel becomes horizontal.

It seems scarcely necessary to say that under no circumstances whatever should a second kite be attached that does not pull *above* the main line and thus tend to lift it. To attach a subordinate kite that pulls *below* the main line, and therefore drags it lower, would, obviously, be absurd if we aim to attain great elevations.

The total elevation attained by the tandem of two kites is, from equations (23) and (10),

$$H_2 = \frac{t}{w} \left(1 - \frac{\cos. \theta}{\cos. \theta'} \right) + \frac{t_2}{w} (1 - \cos. (\theta' + a))$$

This equation can be transformed into the following:

$$H_2 = \frac{t}{w} \left\{ \begin{aligned} &1 - R + \sqrt{1 + R^2 + 2R \cos. (\theta - \theta')} \\ &- \cos. \theta' [R + \cos. (\theta - \theta')] \\ &+ \sin. \theta' \sin. (\theta - \theta') \end{aligned} \right\} \quad (30)$$

Where $R = \cos. \theta \div \cos. \theta'$.

Equation (30) expresses the maximum height that can be attained by two equal kites in terms depending upon the power of one of the kites and the point at which the second kite is attached to the main line.

The answers to questions (1) and (2), propounded above, are reached from a consideration of equations (28) and (30), as follows:

Best utilization of a given pull.—Assume that the two kites are attached side by side on the end of the main line. In this case,

$$\theta' = \theta, \text{ and } R = 1,$$

¹ MONTHLY WEATHER REVIEW for April, 1896.

whence the height becomes,

$$H_2 = \frac{2t}{w} (1 - \cos. \theta),$$

which means that, thus arranged, the two kites attain twice the elevation of one alone, as should be the case. To show the effects of attaching the second kite lower and lower down upon the main line, we will compute the relative heights attained when the second kite is attached after the line has sagged 10° , 20° , 30° , and including the case where the second kite is not attached until the top kite has carried up all the wire it can sustain, in which case $\theta' = 0$. We will assume that the kites pull at an angle $\theta = 55^\circ$, and compute the elevations on the basis of the maximum height being 5,000 feet. The results are:

		Feet.	Loss. Feet.
Maximum effect, both kites at the top.....	$H_2 = 5,000$	.....
Second kite attached where the sag is 10° , $\theta' = 45^\circ$	$H_2 = 4,960$	40	
" " " " 20° , $\theta' = 35^\circ$	$H_2 = 4,850$	150	
" " " " 30° , $\theta' = 25^\circ$	$H_2 = 4,690$	310	
" " " " 40° , $\theta' = 15^\circ$	$H_2 = 4,470$	530	
" " " " 50° , $\theta' = 5^\circ$	$H_2 = 4,200$	800	
" " " " 55° , $\theta' = 0^\circ$	$H_2 = 4,040$	960	

We find here that there is a continually increasing loss in the elevation attained when flying kites tandem, depending upon how much the line is permitted to sag before the second kite is attached. The best results correspond to the least sag of the wire between kites, and the maximum effect is obtained when $\theta' = \theta$; but this may mean either of two things: (1) that the kites are placed side by side at the end of the line or (2) that innumerable kites are attached along the line so close to each other that the line does not sag between them; in other words, that every particle of the line is acted upon by its kite just as it is by gravity. From the properties of the catenary thus brought out it results that the maximum service can not be obtained by flying kites in tandem. There are, however, from other considerations, many marked advantages in tandem flying, which consist in the greater steadiness of pull thereby secured under actual conditions of variable winds and greater security against accident; also the facility of using a large or small amount of sustaining surface as required by conditions of wind force. A special advantage results from the more equable distribution of the strain on the line, which otherwise, with a single kite, is a maximum at the top. In reeling in a long line of kites, it is an advantage to be able to lessen the opposing pull by the removal of one after another of the kites, rather than to have to wind them all in until the top end is reached. Notwithstanding such advantages, we must not lose sight of the marked superiority of one large kite at the end of the line when we aim to reach great elevations. Perhaps more will be gained by the use of two, to secure a more steady pull, than will be lost by virtue of the tandem arrangement, but these two kites are best placed near the top end of the line.

In connection with equation (30) it is instructive to notice the result when $\theta = 90^\circ$. This is not attainable by kites but represents the case of captive balloons in perfectly still air, and upon the supposition that the balloons pull with a constant force at all elevations. No matter what value θ' may have between 0° and 90° , the equation shows that two balloons in tandem will go twice as high as one, etc. Furthermore, it will be found that equation (30) shows that less loss results in tandem arrangements the steeper the angle at which each kite pulls, that is, the greater the value of θ .

While equation (30) was deduced for but two kites it answers perfectly for the analysis of the effects of any number of kites, for having found the result of the combination of two kites this combination may be treated as one and combined with a third kite, etc.

Thus far our consideration of tandem flying has been confined wholly to the question, how much effect can be produced by a certain pull, and we have found that the maximum elevation is attained either by concentrating the pull wholly at the outer end of the line) and this is the only feasible arrangement) or by acting with a portion of the pull upon each particle of the wire just as gravity acts to pull it down.

Best utilization of a given line.—We will next consider the second question that arises in connection with tandems, namely, how to best employ a line of given strength to attain elevation. If we attach at the end of the given line a kite so large that its pull strains the line to its safe working limit, a second kite can not be attached without danger to the line, except at some point well down upon the line, where, by reason of the diminution of the tension in the line corresponding to its deeper and deeper sag, the combined pull of the two kites will not exceed the safe working strength of the line. The second kite can not, in any case, pull as much as the first kite, but may be larger and larger the more and more the line is permitted to sag. Equation (28), inverted, tells us how much a kite it is proposed to add, can pull without exceeding the strength of the line; t , in that equation becomes T , the working tension that the line can sustain; θ is the direction or inclination of the pull to the horizontal; θ' is the inclination and t' the tension of the wire at the point where the second kite is to be attached. The pull of the top kite has already been assumed to be $T =$ the strength of the line, and if θ'' is the inclination of this pull, then since

$$t' = T \frac{\cos. \theta''}{\cos. \theta'} = TR_1,$$

we get,

$$t = T \left[\sqrt{1 - R_1^2 (1 - \cos. (\theta - \theta'))} - R_1 \cos. (\theta - \theta') \right] \quad (31)$$

Equation (31) shows that the second kite can pull the hardest if it is attached where the main line has sagged down to the horizontal condition; that is, where $\theta' = 0$; but we have already found that this is the opposite of the conditions that must be satisfied to attain high elevations. The final conclusions are plain, namely: (1) To utilize a given pull to the best advantage it must be concentrated at the end of the line; (2), to attain the maximum elevation with a line of a given strength every part of it must be subjected to the maximum strain that it can sustain. In other words, we must attach the largest kite the line can carry at the top end, and then little by little, as the line sags and the tension thereon diminishes, the tension must be increased up to the safe limit by additional kites. Equation (31) applies broadly to all cases, and is independent of the weight of the line per unit length, which means that we need consider only T , the maximum safe working tension of the particular line that is employed, thus embracing the case where fine lines at the start are joined to stronger lines as the pull increases.

The wind-impressed catenary.—The special results brought out in the foregoing application of the properties of the catenary to kite flying are not strictly the exact results that will be attained in practice, because we have neglected to include the effect of the wind upon the wire, as we are forced to do by the limitation of our knowledge concerning its pressure upon long fine wires. It seems that some knowledge of this total effect might be gained by a comparison of the actual behavior of kites whose constants are fully known with those effects which our knowledge of the properties of the catenary show should result. The experimental work of the Weather Bureau has not as yet been carried sufficiently far to furnish data of this nature, but the matter has been carefully considered from this standpoint with a view of deducing what may be called a correction for wind effect on the wire.

The general nature of the action of the wind upon the wire,

and its effects in modifying the catenary may be shown in a more or less satisfactory manner, as follows: Let Fig. 79 represent a catenary subjected to the action of the wind. Along the lower portions of the curve the wind effect is very slight, both because the inclination of the wire is small, and as a rule, the force of the wind near the ground is less than throughout the upper portions of the curve where the effect of the wind pressure upon the wire will be greater, both because of the steeper inclination of the latter and the greater force of the wind. We can not conceive that any appreciable friction arises in the flow of the wind over the wire, and as a result the wind pressure must be normal to the wire at every point. Let the pressure upon a small element of the wire at p be represented by the line $p v$. Also let $p g$ represent the weight of the same element. The effect will then be the same as if the element in question were acted upon by a single force $p r$, which is the resultant or combined effect of the two forces of wind and gravity. Drawing in a similar manner the resultant pressure at other points of the curve we see that the curve assumed by the wire must be one that results from the action of a nearly constant force, which tends to press the wire in a direction such as $P R$. If we consider only a portion of the catenary $A B$, such as might be involved in a partial ascension, we may plainly, with but little error, assume that the combined effects of wind and gravity act in the direction $P R$. In such a case the resulting curve will be sensibly the same as would result if we imagine that gravity alone acted, not in a vertical direction, but in the direction of the line $P R$. In other words, the general form of the curve will be given by the equations we have already deduced, if we imagine the origin of coordinates to be shifted to a new position as $O' Y'$, $O' X'$, which are parallel and perpendicular to the line $P R$. The tension, also, will be given approximately by those equations if we imagine w to be increased in proportion to the ratio of the lines $p r$ to $p g$.

A very simple way of experimentally studying the effects that result from shifting the origin of coordinates in the manner mentioned as applied to kites, consists in laying off on a drawing board an inclined line, $A B$, representing the angular elevation of the kite under consideration. Draw $A B'$, forming the angle θ' with the horizontal, and representing the inclina-

tion of the wire at the reel. Placing the drawing board on edge and suspending a small chain next its surface we may produce in a beautiful manner the curve of the catenary that shall make the angle θ' at the reel, and we may locate its point of crossing the line at B . Fixing these points of the chain by pins or otherwise, it will be found that by raising one edge so that the board stands on its corner, thereby inclining the line $A B$ at different angles in a vertical plane we cause important changes in the inclination of the chain at its fixed points. In order to restore the original inclination, preserving still the same length of chain between the points $A B$, and the upper extremity of the chain upon the line $A B$, it will be found necessary to make the end B approach A as the line $A B$ is made more and more nearly horizontal. These suggestions suffice to show a very simple method that has been employed in several ways by the writer to study the wind affected catenary.

Until the experimental observations have given accurate data concerning the magnitude of the wind effect, it will not be desirable to attempt to deduce equations representing the combined action of, wind and gravity. This interesting and important branch of the kite problem must be left for solution in the future.

In this discussion of the theory and practice of flying kites for scientific purposes, the writer has aimed to show how the well known forces of nature act in producing the more important effects commonly observed in kite flying and to point out those general and fundamental principles of physics and mechanics pertaining to kites, by the proper application of which principles we may expect to secure the maximum useful results according to the requirements of any particular case. The groundwork we have aimed to lay for this work is not as complete as we could wish, owing to the limited time available for the Weather Bureau kite experiments, but it is hoped to extend the work to more promising forms of kites than those that have thus far been employed.

The Editor of the REVIEW has shown a deep personal interest in both the kite experiments themselves and in the publication of this series of articles in the REVIEW and the writer wishes to acknowledge the benefits that have resulted from his careful revision of the manuscript and proof.

NOTES BY THE EDITOR.

THE ST. LOUIS TORNADO.

The great tornado of May 27, 1896, at St. Louis will long continue to furnish material for interesting articles and reminiscences, and the Editor hopes to select from these such items as may be of value to meteorology. The following is extracted from an excellent article in the Occident, by Prof. E. S. Holden, Director of the Lick Observatory. Professor Holden's remarks as to the forecasting of this tornado by the Weather Bureau are omitted, as these forecasts were disseminated much earlier and more widely than he was aware of.

During the month of May I was in St. Louis and was an eye witness of the destruction caused by the great tornado of May 27. In former years, 1881 to 1885, I was stationed at the Washburn Observatory of the University of Wisconsin (Madison), which lies in a region subject to tornadoes, and made it my business to study the causes and effects of these violent local storms so far as opportunity offered.

On the afternoon of May 27 I was in Forest Park in St. Louis with one of my daughters, about 3 o'clock, and the aspect of the sky at once reminded both of us of the "tornado-skies" we had been used to see. The upper sky was covered with a faint veil of grayish clouds parted into regular shapes roughly rectangular and some four or five degrees on a side. Between these figures were darker lanes, of gray-blue color. All around the visible horizon, from north, through west, to south,

there was a rim of brassy lurid sky. In the west, or a little north of west and also in the southwest, were two heavy, black, towering clouds, roughly rectangular in figure. The aspect of these clouds was carefully watched to see if they sent out fibrous, twisted offshoots downward; and the brassy rim of sky next the horizon was examined to see if the color deepened toward green.

Either of these signs would, so far as our previous experience went, have indicated the coming of a veritable tornado. So long as they were absent the indications were for a severe thunderstorm later in the evening. It was "hurricane weather" and not "tornado weather" at first. A little before 4 o'clock the sky looked decidedly more threatening and I decided to take my daughter to the Southern Hotel, which I knew to be one of the stoutest structures in the city. My rooms were on the eastern side, the safer side, which relieved the slight feeling of anxiety somewhat.

My own experience was sufficiently exciting. As I have said, our rooms were on the lee side of the hotel facing a street running north and south. Loaded wagons in the street below were blown off their wheels, and the horses thrown down. The heavy iron cornice of a tall building in course of construction was hurled to the street and destroyed; another building was set on fire by lightning which entered by the wires on the roof; the hotel chimney-stack was blown down, causing a damage to glass, etc., of some \$5,000 and wounding several employees, etc.

The wind first blew violently up the street (north) and after the center of the storm had passed it suddenly changed direction and blew south, and this change of direction made new wrecks. The winds in such a storm blow circularly round, or toward the vortex, and when

their direction is suddenly reversed like this, one recognizes that at least the crisis is half over. I saw very little hail. The occurrence of a violent storm in a city produces any number of strange happenings, freaks, and the published accounts of it usually dwell on these comparatively unmeaning details—freaks—which give no real idea even of the violence of the wind.

I took the time to visit, personally, the ruined parts of the city. The chief damage was done, not by the direct force of the winds from outside, but by the bursting of the houses from the inside. The barometric pressure in the vortex was very low. The pressure inside the houses was comparatively high. It was usually relieved by the bursting of the walls and windows. When these were uncommonly strong the roofs were lifted and, so soon as the pressure was equalized, dropped down nearly in their former positions. Whole blocks and squares were ruined in this fashion, so that not one house in ten was even habitable. The trees in Lafayette Park were mostly overthrown. The leaves on those left standing were blown into tatters, so that only the midrib with ragged portions on each side were left. This instance will, I think, illustrate the force of the wind as well as any other. The gyratory forces were by no means so well marked in this storm as in others that I have studied. It was not a typical tornado, though it partook of the tornado character.

Tornadoes are caused somewhat as follows: The atmosphere above a considerable region of country is in unstable equilibrium. The colder

and heavier air is above, the warmer below. Anywhere in this large region tornadoes may occur. Tornadoes are local effects caused by the effort to establish a stable equilibrium quickly. They partake of the rotation of the large circular air movement, and revolve, as these do, in a direction counter clock-wise. Such rotations are produced in the large movements by the earth's rotation, but tornadoes are too small to be directly affected by the rotation of the earth. Their rotatory motion is probably determined by that of the general mass of air of which they form a part. The centrifugal force of their rotation tends to produce a vacuum in the center of the tornado. The surrounding air can not enter at the sides of the gyrating column; it therefore rushes in at the bottom and blows towards the center and upwards. In violent tornadoes the barometer may be about three inches below the normal. (At St. Louis it was about an inch lower.) The local tornado, thus inadequately and summarily described, is usually less than three hundred yards wide, and the winds within it and around it blow a hundred or more miles per hour. The storm itself travels in the general direction from S.W. to N.E. seldom more than 40 or 50 miles per hour.

Warning of such a storm can be given by building a telegraph line some 3 or 4 miles outside of a village around the dangerous quadrant (the southwest quadrant).

A little piece of apparatus, a rough pressure-gauge, breaks the telegraph wire when the wind blows at a dangerous rate; and the breaking of the wire rings bells wherever one chooses to place them. An arrangement of this sort was in working order at the Washington Observatory for several years, and could be placed so as to warn any small village.

METEOROLOGICAL TABLES.

By A. J. HENRY, Chief of Division of Records and Meteorological Data.

Table I gives, for about 130 Weather Bureau stations making two observations daily and for about 20 others making only the 8 p. m. observation, the data ordinarily needed for climatological studies, viz, the monthly mean pressure, the monthly means and extremes of temperature, the average conditions as to moisture, cloudiness, movement of the wind, and the departures from normals in the case of pressure, temperature, and precipitation.

Table II gives, for about 2,400 stations occupied by voluntary observers, the extreme maximum and minimum temperatures, the mean temperature deduced from the average of all the daily maxima and minima, or other readings, as indicated by the numeral following the name of the station; the total monthly precipitation, and the total depth in inches of any snow that may have fallen. When the spaces in the snow column are left blank it indicates that no snow has fallen, but when it is possible that there may have been snow of which no record has been made, that fact is indicated by leaders, thus (. . .).

Table III gives, for about 30 Canadian stations, the mean pressure, mean temperature, total precipitation, prevailing wind, and the respective departures from normal values. Reports from Newfoundland and Bermuda are included in this table for convenience of tabulation.

Table IV gives detailed observations at Honolulu, Republic of Hawaii, by Curtis J. Lyons, meteorologist to the Government Survey.

Table V gives, for 26 stations, the mean hourly temperatures deduced from thermographs of the pattern described and figured in the Report of the Chief of the Weather Bureau, 1891-'92, p. 29.

Table VI gives, for 26 stations, the mean hourly pressures as automatically registered by Richard barographs, except for Washington, D. C., where Foreman's barograph is in use. Both instruments are described in the Report of the Chief of the Weather Bureau, 1891-'92, pp. 26 and 30.

Table VII gives, for about 130 stations, the arithmetical means of the hourly movements of the wind ending with the respective hours, as registered automatically by the Robinson anemometer, in conjunction with an electrical recording

mechanism, described and illustrated in the Report of the Chief of the Weather Bureau, 1891-'92, p. 19.

Table VIII gives the danger points, the highest, lowest, and mean stages of water in the rivers at cities and towns on the principal rivers; also the distance of the station from the river mouth along the river channel.

Table IX gives, for all stations that make observations at 8 a. m. and 8 p. m., the four component directions and the resultant directions based on these two observations only and without considering the velocity of the wind. The total movement for the whole month, as read from the dial of the Robinson anemometer, is given for each station in Table I. By adding the four components for the stations comprised in any geographical division one may obtain the average resultant direction for that division.

Table X gives the total number of stations in each State from which meteorological reports of any kind have been received, and the number of such stations reporting thunderstorms (T) and auroras (A) on each day of the current month.

Table XI gives, for 38 stations, the percentages of hourly sunshine as derived from the automatic records made by two essentially different types of instruments, designated, respectively, the thermometric recorder and the photographic recorder. The kind of instrument used at each station is indicated in the table by the letter T or P in the column following the name of the station.

Table XII gives a record of the heaviest rainfalls for periods of five and ten minutes and one hour, as reported by regular stations of the Weather Bureau furnished with self-registering rain gauges.

Table XIII gives the record of excessive precipitation at all stations from which reports are received.

Additional information concerning the tables will be found in the REVIEW for January, 1895.

NOTES EXPLANATORY OF THE CHARTS.

Chart I.—Tracks of centers of low pressure. The roman letters show number and order of centers of low areas. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the 8 a. m. and 8 p. m.,

seventy-fifth meridian time, observations. The queries (?) on the tracks show that the centers could not be satisfactorily located. Within each circle is given the lowest barometric reading reported near the center. A blank indicates that no reports were available. A wavy line indicates the axis of a trough or long oval area of low pressure.

Chart II.—Tracks of centers of high pressure. The roman letters show number and order of centers of high areas. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the 8 a. m. and 8 p. m., seventy-fifth meridian time, observations. The queries (?) on the tracks show that the centers could not be satisfactorily located. Within each circle is given the highest barometric reading reported near the center. A blank indicates that no reports were available. A wavy line indicates the axis of a ridge of high pressure.

Chart III.—Total precipitation. The scale of shades show-

ing the depth of rainfall is given on the chart itself. For isolated stations the rainfall is given in inches and tenths, when appreciable; otherwise, a "trace" is indicated by a capital T, and no rain at all, by 0.0.

Chart IV.—Sea-level isobars, surface isotherms, and resultant winds. The wind directions on this Chart are the computed resultants of observations at 8 a. m. and 8 p. m., daily; the resultant duration is shown by figures attached to each arrow. The temperatures are the means of daily maxima and minima and are not reduced to sea level. The pressures are the means of 8 a. m. and 8 p. m. observations, daily, and correspond to Professor Hazen's system of reduction; the barometer is not reduced to standard gravity, but the necessary reduction for 30 inches of the mercurial barometer is shown by the marginal figures for each degree of latitude.

Charts V, VI, VII, and VIII.—Kite Experiments at the Weather Bureau.

Stations.	Elevation above level, feet.	Length of record, years.	Pressure in inches.		Temperature of the air, in degrees Fahrenheit.				Humidity and precipitation.				Wind.			Monthly temperature data since opening station.															
			Mean pressure, 8 a. m. and 8 p. m.	Mean reduced.	Mean max. and min.	Departure from normal.	Maximum.	Minimum.	Mean.	Greatest daily range.	Mean temperature of the day-point.	Mean relative humidity, per cent.	Precipitation, in inches.	Departure from normal.	Days with .01, or more.	Total movement, miles.	Prevailing direction.	Maximum velocity.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Absolute maximum.	Year.	Absolute minimum.	Year.					
<i>New England.</i>																															
Eastport	76	24	29.88	30.06	+.04	61.8	57.0	64.8	9	70	48	5	53	30	55	85	3.63	0.2	5,598	s.	36	e.	5	7	15	9	6.0	91	1894	45	*
Portland, Me.	103	25	29.85	30.05	+.03	61.8	57.0	64.8	12	70	48	5	53	30	55	85	3.10	0.15	4,856	sw.	30	nw.	31	7	13	11	6.3	97	*	48	1886
Northfield	872	10	29.07	30.08	+.04	61.8	57.0	64.8	13	70	48	5	53	30	55	85	5.99	2.8	5,910	s.	29	nw.	31	4	15	12	6.5	98	1894	38	*
Boston	135	26	29.87	30.04	+.06	61.8	57.0	64.8	13	70	48	5	53	30	55	85	2.90	0.5	7,514	sw.	29	ne.	31	11	9	11	5.4	101	1880	46	1871
Nantucket	14	10	30.00	30.04	+.08	61.8	57.0	64.8	13	70	48	5	53	30	55	85	4.12	1.7	6,772	sw.	28	n.	31	8	13	10	5.4	87	1892	48	1891
Woods Hole	19	10	30.00	30.04	+.08	61.8	57.0	64.8	13	70	48	5	53	30	55	85	2.81	0.3	9,032	s.	38	sw.	11	16	6	9	4.4	90	1876	51	1879
Vineyard Haven.	10	10	30.00	30.04	+.07	61.8	57.0	64.8	13	70	48	5	53	30	55	85	3.59	0.8	13	sw.	38	sw.	11	16	6	9	4.4	90	1876	51	1879
Block Island	27	10	30.01	30.04	+.07	61.8	57.0	64.8	13	70	48	5	53	30	55	85	3.51	0.3	12	sw.	36	sw.	27	3	30	8	6.2	88	1892	62	1895
Narragansett Pier	15	10	30.00	30.04	+.07	61.8	57.0	64.8	13	70	48	5	53	30	55	85	2.15	1.6	11	sw.	36	sw.	27	3	30	8	6.2	88	1892	62	1895
New Haven.	107	34	29.90	30.01	+.04	61.8	57.0	64.8	13	70	48	5	53	30	55	85	3.86	1.1	5,542	sw.	31	ne.	13	14	7	10	5.0	96	1892	49	1890
<i>Mid. Atl. States.</i>																															
Albany	85	26	29.91	30.00	+.07	61.8	57.0	64.8	13	70	48	5	53	30	55	85	3.57	0.4	5,624	s.	26	w.	23	11	14	6	5.3	98	1890	48	1890
New York	314	26	29.70	30.00	+.05	61.8	57.0	64.8	13	70	48	5	53	30	55	85	4.45	0.2	8,767	sw.	30	nw.	27	15	8	8	4.6	99	1878	55	1895
Harrisburg	377	9	29.63	30.00	+.05	61.8	57.0	64.8	13	70	48	5	53	30	55	85	6.82	2.1	4,407	w.	40	n.	6	8	9	14	6.0	98	1892	50	1890
Philadelphia	117	26																													

TABLE I.—Climatological data for Weather Bureau Stations, July, 1896—Continued.

Stations.	Elevation above sea level, feet.	Length of record, years.	Pressure, in inches.		Temperature of the air, in degrees Fahrenheit.					Humidity and precipitation.					Wind.			Monthly temperature data since opening station.														
			Mean pressure, 8 a. m. and 8 p. m. + 2.	Mean reduced.	Departure from normal.	Mean max. and min. + 2.	Departure from normal.	Maximum.	Date.	Mean minimum.	Date.	Mean maximum.	Mean minimum.	Date.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation, in inches.	Departure from normal.	Days with .01, or more.	Total movement, miles.	Prevailing direction.	Maximum velocity.		Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Absolute maximum.	Year.	Absolute minimum.	Year.	
																						Miles per hour.	Direction.									
<i>Op. Miss. Val.—Con</i>																																
Hannibal	534	36	29.45	30.00	.....	76.1	.....	96	29	86	54	8	67	27	66	73	9.44	+ 6.3	14	5,759	sw.	36	ne.	31	16	11	4	4.1	.....	.....	.....	.....
St. Louis	571	36	29.45	30.05	+ .06	79.0	.....	98	30	88	58	17	70	24	68	73	4.67	+ 0.9	13	6,832	s.	41	sw.	31	16	8	7	4.4	104	1881	55	1891
<i>Missouri Valley.</i>																																
Columbia	963	7	29.03	30.02	.....	77.4	+ 1.2	97	31	88	53	9	66	32	.....	.....	3.79	+ 1.1	11	4,814	s.	23	sw.	18	10	11	10	5.3	105	1894	45	1892
Kansas City	1,063	9	29.03	30.02	+ .05	77.4	+ 1.1	97	31	86	58	25	68	27	.....	.....	8.06	+ 4.5	8	5,266	s.	40	sw.	3	9	16	6	4.8	102	1890	54	*
Springfield, Mo.	1,324	10	29.07	30.02	+ .04	77.4	+ 1.0	95	27	86	57	8	69	22	66	70	2.98	+ 1.8	8	6,090	se.	25	se.	3	8	18	5	4.5	99	1888	53	1891
Topeka	1,165	10	29.43	30.00	.....	78.2	+ 1.2	99	3	88	58	25	68	28	.....	.....	5.54	+ 0.7	10	.....	s.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Omaha	1,123	26	29.85	30.00	+ .03	74.6	+ 2.5	96	2	83	56	24	66	26	63	71	4.53	+ 0.2	10	5,221	n.	30	nw.	26	15	8	8	4.6	106	1894	50	1895
Sioux City	1,165	8	29.43	30.00	.....	72.4	+ 2.2	97	14	83	52	24	62	31	.....	.....	5.54	+ 2.2	10	6,126	se.	52	nw.	26	12	13	6	4.8	107	1894	41	1895
Pierre	1,470	22	29.43	29.94	+ .08	73.5	+ 1.6	101	11	85	54	24	62	31	.....	.....	3.39	+ 1.2	7	6,762	e.	40	nw.	3	6	14	11	5.5	110	1896	45	1895
Huron	1,310	16	28.61	29.97	+ .03	70.0	+ 2.2	99	12	82	49	22	58	38	57	67	1.62	+ 1.5	10	7,934	se.	40	se.	28	7	21	3	4.8	108	1894	41	1891
<i>Northern Slope.</i>																																
Havre	2,477	16	27.28	29.90	+ .02	69.4	+ 1.5	98	10	83	40	24	55	43	48	53	0.66	+ 1.6	3	4,676	nw.	42	ne.	19	21	7	3	3.5	108	1886	31	1892
Miles City	2,372	19	27.49	29.89	.....	72.1	+ 1.6	98	11	86	44	24	58	41	53	57	1.29	+ 0.1	8	4,642	n.	36	nw.	2	15	9	7	4.1	109	1881	42	1895
Helena	4,108	17	25.92	29.90	+ .06	68.6	+ 2.1	95	6	90	44	22	57	35	43	47	0.89	+ 0.2	7	5,065	sw.	35	sw.	12	19	7	5	3.3	108	1886	38	1890
Rapid City	3,260	11	26.67	29.92	+ .01	71.8	+ 1.1	100	12	84	50	24	60	36	53	57	1.73	+ 0.0	12	6,284	n.	38	sw.	2	6	16	9	5.9	106	1881	37	1881
Cheyenne	6,105	26	24.14	29.92	+ .03	68.6	+ 1.8	99	13	79	50	*	54	36	48	56	6.35	+ 4.6	14	6,194	s.	38	se.	1	6	20	5	5.2	100	1881	38	*
Lander	5,872	9	24.75	29.96	+ .04	68.0	+ 1.4	95	12	82	45	31	54	39	45	52	3.00	+ 2.2	10	2,921	sw.	30	sw.	30	6	19	6	5.4	99	1888	34	1889
North Platte	2,826	22	27.13	29.97	+ .04	72.6	+ 1.4	95	14	84	54	19	61	34	61	72	1.86	+ 0.9	5	6,182	se.	42	nw.	20	9	20	2	4.7	107	1877	42	1889
<i>Middle Slope.</i>																																
Denver	5,290	25	24.85	29.96	+ .09	71.9	+ 0.9	96	13	85	53	9	59	34	48	54	2.80	+ 1.1	12	5,337	ne.	45	nw.	25	9	18	4	4.7	102	1874	42	1873
Pueblo	4,713	9	25.25	29.93	+ .04	75.0	+ 0.5	96	21	89	56	9	61	38	48	49	2.08	+ 0.1	12	5,190	nw.	38	nw.	7	11	16	4	4.9	103	1888	49	1895
Concordia	1,410	12	28.53	29.96	+ .01	76.9	+ 0.2	98	2	87	58	9	67	29	65	72	9.27	+ 6.1	13	4,531	s.	21	s.	22	6	18	7	5.3	104	1894	46	1895
Dodge City	2,594	22	27.43	29.94	+ .08	77.6	+ 0.9	100	29	89	57	24	66	34	63	69	5.41	+ 2.8	14	8,269	se.	37	se.	23	14	13	4	4.5	108	1876	50	1877
Wichita	1,851	9	28.59	29.97	+ .03	78.4	+ 1.1	99	*	88	60	25	69	28	66	72	3.40	+ 0.8	11	4,541	s.	27	s.	23	15	7	9	4.2	104	1894	53	1892
Oklahoma	1,239	6	28.75	30.01	+ .06	80.7	+ 1.0	101	27	92	61	9	70	33	67	71	1.81	+ 2.0	8	5,901	s.	24	n.	24	17	12	2	3.2	104	1894	56	1891
<i>Southern Slope.</i>																																
Abilene	1,749	11	28.24	30.00	+ .04	82.8	+ 0.6	99	4	93	66	10	72	29	61	55	1.68	+ 0.0	7	7,071	s.	31	se.	11	14	14	6	4.3	110	1886	62	*
Amarillo	3,691	11	26.34	29.98	+ .08	74.5	+ 0.9	92	23	85	50	11	64	31	58	65	7.04	+ 4.9	10	11,803	s.	56	w.	14	12	9	10	5.6	.....	.....	.....	.....
<i>Southern Plateau.</i>																																
El Paso	3,767	19	26.22	29.92	+ .05	79.5	+ 4.2	96	24	91	64	8	68	30	57	57	2.73	+ 0.6	15	6,875	e.	49	ne.	17	9	17	5	5.1	112	1886	56	1880
Santa Fe	6,998	23	23.43	29.97	+ .05	66.8	+ 2.4	82	8	77	52	13	56	27	49	58	3.78	+ 1.0	14	4,281	se.	34	sw.	27	2	19	10	6.3	96	1878	46	*
Phoenix	1,096	23	28.71	29.83	.....	88.0	+ 1.5	109	9	100	69	21	76	32	61	49	4.25	+ 3.4	13	3,550	w.	48	se.	14	11	14	6	5.0	.....	.....	.....	.....
Yuma	139	21	29.64	29.78	+ .02	91.3	+ 0.2	110	*	105	68	30	78	38	62	45	0.41	+ 0.3	2	5,123	sw.	33	ne.	21	25	3	3	3.0	118	1878	61	1879
<i>Middle Plateau.</i>																																
Carson City	4,720	9	25.34	29.97	.....	69.3	+ 1.6	97	19	87	42	30	52	42	45	53	0.63	+ 0.5	7	.....	w.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Winnemucca	4,340	18	25.68	29.90	+ .05	73.4	+ 2.5	98	10	88	44	30	59	44	32	29	0.29	+ 0.1	5	6,896	sw.	48	s.	12	30	7	4	3.1	104	1877	37	1877
Salt Lake City	4,344	23	25.67	29.91	+ .04	74.2	+ 1.3	97	11	86	55	30	62	34	49	46	1.35	+ 0.8	8	4,108	se.	34	e.	5	9	11	11	6.0	102	1880	45	1891
<i>Northern Plateau.</i>																																
Baker City	3,470	8	26.46	29.86	+ .02	69.8	+ 3.2	96	5	85	47	24	54	40	48	52	0.97	+ 0.4	5	3,733	s.	26	nw.	6	19	9	3	2.9	101	1890	36	1895
Idaho Falls	4,742	7	25.29	29.92	+ .03	69.6	+ 2.0	95	11	86	46	1	53	44	44	50	1.16	+ 0.8	5	5,896	n.	34	s.	22	13	12	6	4.1	99	1893	32	1893
Spokane	1,990	16	27.96	29.92	.....	73.2	+ 4.2	100	15	87	50	23	59	39	42	42	0.17	+ 0.5	2	3,711	ne.	26	ne.	21	30	8	3	2.8	102	1890	41	1897
Walla Walla	1,018	11	28.86	29.90	+ .04	79.1	+ 3.9	106	15	93	51	22	65	39	52	42	0.15	+ 0.2	3	3,640	s.	24	sw.	5	27	4	0	2.0	108	1891	45	1891
<i>N. Pac. Coast Reg.</i>																																
East Clallam	.....	.....	.....	.....	.....	63.3	+ 2.3	.....	80	18	67	43	1	50	30	.....	0.00	.....	0	.....	w.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Fort Canby	179	13	29.88	30.07	+ .01	61.2	+ 2.6	77	19	67	52	11	56	19	56	86	0.00	+ 1.1	0	5,102	n.	35	n.	13	12	9	10	4.9	90	1895	46	1887
Neah Bay	.....	.....	.....	.....	.....	60.2	+ 0.9	75	21	69	46	2	51	25	.....	.....	0.08	+ 1.9	1	.....	sw.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Port Angeles	29	12	30.00	30.03	.....	58.9	+ 2.3	79	19	66	44	29	52	26	50	74	0.00	+ 0.4	0													

TABLE II.—Meteorological record of voluntary and other cooperating observers, July, 1896.

Stations.	Temperature. (Fahrenheit.)			Precipitation.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
Alabama.					
Alco ⁺	98	65	80.5	Ins.	Ins.
Ashville ⁺	105	66	83.0	2.22	
Bermuda ⁺	99	64	80.0	5.00	
Birmingham ⁺	101	63	82.4	3.35	
Brewton ⁺	102	63	80.2	9.35	
Carrollton ⁺	96	67	80.8	4.59	
Citronelle ⁺	98	69	81.6	4.45	
Clanton ⁺	97	65	80.3	4.01	
Cordova ⁺				3.92	
Daphnet ⁺	99	67	81.6	9.38	
Decatur ⁺	102	54	80.2	2.26	
Demopolis ⁺				1.95	
Elba ⁺	104	63	80.2	7.18	
Eufaula ⁺	99	65	82.7	10.25	
Evergreen ⁺	98	64	80.7	8.85	
Florence ⁺				2.70	
Florida ⁺	99	51	80.1	3.78	
Fort Deposit ⁺	99	66	82.2	5.75	
Goodwater ⁺	102	63	81.4	4.57	
Greensboro ⁺	100	65	81.8	2.39	
Hamilton ⁺				3.28	
Healing Springs ⁺	99	67	78.9	4.21	
Highland Home ⁺	98	67	80.1	6.73	
Jasper ⁺				3.69	
Livingston ⁺	100	62	83.4	2.69	
Lock No. 4 ⁺				5.85	
Madison Station ⁺	98	50	78.8	3.41	
Maple Grove ⁺	97	68	81.3	3.72	
Marion ⁺	99	64	81.9	5.26	
Mount Willing ⁺	100	65	81.0	5.65	
Newbern ⁺	100	68	82.2	2.07	
Newburg ⁺	104	54	80.4	3.26	
Newton ⁺	99	64	80.1	12.57	
Oneonta ⁺	103	53	78.9	9.53	
Opelika ⁺	95	64	79.6	5.54	
Oxanna ⁺	97	62	79.8	4.25	
Pineapple ⁺	103	64	81.9	4.47	
Pushmataha ⁺	103	63	83.2	1.20	
Rock Mills ⁺	99	62	80.2	7.58	
Scottsboro ⁺	100	58	80.8	4.89	
Selma ⁺				3.90	
Talladega ⁺	98	66	81.1		
Thomasville ⁺	103	68	82.8	3.62	
Tuscaloosa ⁺	105	63	83.8	4.00	
Tusculum ⁺	102	60	81.8	2.78	
Union ⁺	103	62	81.8	3.03	
Union Springs ⁺	100	65	82.3	9.01	
Uniontown ⁺	102	67	83.0	1.05	
Valleyhead ⁺	96	54	78.4	6.12	
Wetumpka ⁺				5.69	
Wilsonville ⁺				1.18	
Alaska.					
Killisnoot ⁺	67	39	52.8	2.05	
Arizona.					
Antelope Valley ⁺				4.32	
Arizona Canal Co. Dam ⁺	110	63	85.1	3.24	
Benson ⁺	104	73	84.8	2.55	
Bisbee ⁺	98	60	75.7	4.29	
Buckeye ⁺	108	70	87.2	4.10	
Calabasas ⁺	99	60	78.2	5.92	
Casa Grande ⁺	100	77	87.8		
Dragoon ⁺				2.70	
Dragoon Summit ⁺	91	67	79.8	2.04	
Dudleyville ⁺	104	65	83.2	2.40	
Eagle Pass ⁺				3.75	
Farley's Camp ⁺	109	68	87.2	2.89	
Flagstaff ⁺	84	45	66.0		
Fort Apache ⁺	96	50	72.9	4.31	
Fort Grant ⁺	98	55	77.8	1.88	
Fort Huachuca ⁺	96	48	74.2	3.73	
Fort Mohave ⁺	120			0.15	
Gilabend ⁺	113	80	94.9	2.45	
Glendale ⁺	108	69	87.2		
Holbrook ⁺	95	53	71.6	2.36	
Inglewood ⁺	113	69	89.9	2.19	
Maricopa ⁺	117	80	96.9	1.18	
Mesa ⁺	110	54	83.4	8.40	
Mount Huachuca ⁺	95	59	75.5	6.77	
Natural Bridge ⁺				2.32	
Oracle ⁺	100	64	79.2	2.48	
Oro ⁺				2.28	
Oro Blanco ⁺	95	70	80.9	5.79	
Pantano ⁺	97	74	86.0	1.38	
Parker ⁺	118	60	95.4	T.	
Payson ⁺				4.22	
Peoria ⁺	112	72	89.3	3.14	
Phoenix ⁺	109	67	86.6	3.66	
Pinel Ranch ⁺				4.04	
Reymert ⁺	117	69	90.4	2.67	
St. Helena Ranch ⁺	96	64	80.0	6.26	
San Carlos ⁺	108	62	85.2	3.78	
San Simon ⁺	103	69	83.9	0.57	
Showlow ⁺				1.44	
Signal ⁺	112	63	89.4	2.36	
Sulphur Spring Valley ⁺				3.07	
Texas Hill ⁺	120	70	94.4	1.15	
Arizona—Cont'd.					
Tucson ⁺	104	67	85.0	3.45	
Walnut Grove ⁺				0.13	
Walnut Ranch ⁺	90	61	72.7	6.92	
Wells ⁺	113	70	89.4	3.34	
Whipple Barracks ⁺	95	49	72.0	4.70	
Willcox ⁺	98	60	82.5	1.46	
Arkansas.					
Arkansas City ⁺				0.90	
Beebranch ⁺	105	57	82.7	2.10	
Blanchard Springs ⁺	102	58	84.4	1.34	
Brinkley ⁺	103	57	84.4	0.92	
Camden ⁺				0.80	
Camden ⁺	106	56	84.6	0.86	
Conway ⁺	101	65	83.1	0.95	
Corning ⁺	101	58	80.0	7.50	
Dallas ⁺	108	56	82.8	2.90	
Dardanelle ⁺				1.21	
Elon ⁺	105	58	85.4	0.00	
Fayetteville ⁺	105	55	82.2	0.77	
Forrest ⁺	103	59	82.7	0.78	
Fulton ⁺				1.40	
Gaines Landing ⁺				1.77	
Helena ⁺				0.33	
Helena ⁺	104	61	85.6	0.34	
Hot Springs ⁺	104	65	85.6	1.20	
Hot Springs ⁺				1.63	
Hot Springs (near) ⁺				1.81	
Jonesboro ⁺	102	57	81.4	1.72	
Keesee Ferry ⁺	106	53	81.2	4.56	
Kirby ⁺	105	60	85.0	2.30	
Lacroset ⁺	103	55	81.1	1.16	
Latour ⁺				2.02	
Lonoke ⁺	106	63	86.9	2.56	
Luna Landing ⁺	98	63	83.0	1.73	
Malvern ⁺	110	56	86.2	1.00	
Marvell ⁺	104	60	85.0	2.69	
Marsville ⁺	97	59	80.4	3.40	
Mount Nebo ⁺	95	67	80.6	1.30	
New Gascony ⁺				0.20	
Newport ⁺				2.99	
Newport ⁺	104	58	81.4	1.77	
Newport ⁺	104	54	82.2	2.79	
Oceola ⁺	98	60	81.5	2.53	
Ozark ⁺	108	64	87.1	0.66	
Pocahontas ⁺	102	59	85.6	1.34	
Pinebluff ⁺	106	59	85.6	0.48	
Pocahontas ⁺	101	56	80.0	1.99	
Prescott ⁺	107	63	86.2	2.78	
Russellville ⁺	102	61	83.6	4.76	
Silver Springs ⁺	102	52	79.4	0.76	
Stuttgart ⁺	107	60	84.0	1.21	
Texarkana ⁺	100	66	84.6	0.10	
Warren ⁺	107	57	85.8	1.25	
Washington ⁺				0.76	
Wiggs ⁺	106	63	86.3	0.80	
Witts Springs ⁺	99	54	79.5	0.61	
California.					
Adin ⁺	98	42	70.5	0.27	
Agnew ⁺	90	44	66.6	0.21	
Arlington Heights ⁺	102	52	76.0	0.01	
Athlone ⁺	116	64	88.4	T.	
Azusa ⁺				0.07	
Ballast Point L. H. ⁺				0.00	
Barstow ⁺	108	44	76.5	0.07	
Beaumont ⁺				0.72	
Berkeley ⁺	81	52	64.6	T.	
Bishop ⁺	99	47	71.4	0.61	
Bishop Creek ⁺	105	62	83.4	0.57	
Boca ⁺	98	40	63.2	1.15	
Bodie ⁺	85	37	59.2	1.01	
Bowmans Dam ⁺				0.09	
Caliente ⁺	109	67	89.4	0.05	
Calloway Canal ⁺				0.09	
Cape Mendocino L. H. ⁺				0.00	
Cedarville ⁺	97	46	71.7	0.49	
Centerville ⁺	103	60	79.6	0.10	
Chico ⁺	108	58	84.9	0.00	
Chino ⁺	100	62	76.7	0.00	
Cisco ⁺	85	49	64.6		
Claremont ⁺	97	46	72.0	T.	
Corning ⁺	115	65	85.9	0.00	
Craftonville ⁺	104	51	79.8	0.00	
Crescent City ⁺	83	44	58.2	0.00	
Crescent City L. H. ⁺				0.00	
Davisville ⁺	105	50	78.8	0.00	
Delano ⁺	108	63	85.9	0.25	
Delta ⁺	108	63	82.1	0.00	
Descanso ⁺	93	36	69.7	0.30	
Drytown ⁺	107	48	80.1	T.	
Dunnigan ⁺	108	62	85.4	0.04	
Durham ⁺	102	60	80.0	0.05	
East Brother L. H. ⁺				0.03	
Edgewood ⁺	102	55	76.5	5.07	
Edmonton ⁺	93	44	65.9	0.08	
Escondido ⁺	105	44	74.8		
Fallbrook ⁺	100	55	71.3	0.05	
California—Cont'd.					
Folsom City ⁺	110	63	82.4	0.00	
Fordey Dam ⁺				0.95	
Fort Bragg ⁺				0.04	
Fort Ross ⁺				0.00	
Fort Tejon ⁺				0.00	
Georgetown ⁺	96	48	75.9	0.20	
Glendora ⁺				0.09	
Goshen ⁺	112	59	87.0	0.43	
Grass Valley ⁺				0.02	
Greenville ⁺	102	35	69.4	0.61	
Guinda ⁺				0.00	
Healdsburg ⁺	96	50	64.6	0.00	
Hollister ⁺	91	38	64.3	0.00	
Hueneme ⁺				0.03	
Humboldt L. H. ⁺				0.00	
Hydesville ⁺	82	42	59.8	0.00	
Iowa Hill ⁺	100	61	76.3	0.11	
Isabella ⁺	110	50	82.6	2.57	
Jackson ⁺	97	44	75.4	0.04	
Jolon ⁺				0.10	
Keeler ⁺	100	65	85.6	0.25	
Keene ⁺	103	60	81.1	0.15	
Kennedy Gold Mine ⁺	106	48	78.4	0.25	
Kernville ⁺				2.25	
King City ⁺	102	47	65.3	0.00	
Kingsburg ⁺	110	65	87.1	0.30	
Kono Tayee ⁺	96	57	78.6	T.	
Lagrange ⁺	114	55	87.0	0.10	
Laporte ⁺	94	49	66.1	0.31	
Lemoore ⁺	110	62	87.1	0.10	
Lick Observatory ⁺	91	48	73.2	T.	
Lime Kiln ⁺	113	60	87.0		
Lime Point L. H. ⁺				0.01	
Lodi ⁺	105	48	76.5	T.	
Los Alamos ⁺				0.17	
Los Gatos ⁺	100	40	69.3	0.00	
McMullin ⁺	114	60	88.8		
Malakoff Mine ⁺	97	56	75.7	0.06	
Mammoth Tank ⁺	117	85	102.8</		

TABLE II.—Meteorological record of voluntary and other cooperating observers—Continued.

Stations.	Temperature. (Fahrenheit.)			Precipita- tion.		Stations.	Temperature. (Fahrenheit.)			Precipita- tion.		Stations.	Temperature. (Fahrenheit.)			Precipita- tion.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.		Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.		Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
California—Cont'd.						Colorado—Cont'd.						Florida—Cont'd.					
Robertson Mills.	°	°	°	Ins.	Ins.	Gunnison†	°	°	°	Ins.	Ins.	Macclenny†	°	°	°	Ins.	Ins.
Roe Island L. H.						Holly	91	28	60.9	1.37		Manatee†	103	70	83.0	6.25	
Roseville (near) * ³	108	52	82.4	0.00		Holyoke				1.95		Merritts Island†	97	61	79.6	14.36	
Rosewood	108	53	81.0	0.17		Hugo	94	60	76.4	3.28		Milton†	92	71	81.7	2.43	
Sacramento	104	50	76.8	T.		Hugo (near)	88	48	67.8	3.42		Mullet Key†	94	74	83.4	7.43	
Salinas	78	45	60.5	0.00		Husted†	96	45	69.0	3.80		Myers†	91	70	80.8	9.04	
Salton	120	84	101.2	0.18		Kit Carson	98	60	77.0			Oakhill	87	73	80.6		
San Bernardino†	103	49	76.8	T.		La Jara†	85	37	65.0	0.73		Ocala	96	73	80.2	5.02	
San Jacinto†	105	45	77.7	0.07		Lake Moraine†	70	34	54.3	5.00		Orangepark	100			8.32	
San Jose	94	40	69.3	0.01		Lamar	104	50	79.8	1.69		Orlando†	95	69	80.8	10.06	
San Leandro	87	59	66.3	0.04		Laporte				2.47		Oxford	97	72	80.4	4.40	
San Luis L. H.				0.30		Las Animas†	100	80	77.6	1.30		Plant City†	98	68	81.3	8.61	
San Mateo	88	59	69.0	0.00		Lay†	101	35	69.6	3.06		Quincy†	99	74	87.8	10.40	
San Miguel	106	60	78.6	0.00		Leroy†	96	54	72.8	1.33		St. Francis†	99	65	80.4	7.76	
San Miguel Island†	78	50	64.0	0.16		Longmont†	97	50	72.7	1.53		St. Francis Barracks	95	68	80.0	4.97	
Santa Ana	95	62	78.8	0.00		Long Peak	78	36	54.7	3.00		Tallahassee†	96	57	79.6	10.51	
Santa Barbara	80	57	66.9	0.40		Loveland				0.67		Tarpon Springs†	90	70	79.8	8.49	
Santa Barbara L. H.				0.36		Manhattan				2.83		Georgia.					
Santa Clara	88	50	66.0	0.00		Meeker†	101	40	67.9	3.56		Adairsville†	96	56	79.2	6.16	
Santa Cruz	89	42	63.9	0.05		Millbrook†	87	37	64.0	3.38		Alapaha	102	68	82.8	7.34	
Santa Cruz L. H.				0.00		Minneapolis†	104	58	78.4	1.75		Albany†	101	62	82.2	7.06	
Santa Maria	85	50	67.3	0.11		Montrose	96	49	76.4	0.48		Allentown†	103	65	84.2	5.71	
Santa Monica	89	61	72.2	0.00		Moraine†	82	38	59.3	3.88		Americus†	100	66	83.2	9.29	
Santa Paula	86	47	67.3	0.00		Pagoda†	99	35	66.8	3.10		Athens	98	57	80.0	10.31	
Santa Rosa	95	53	73.6	0.00		Paonia†				1.41		Bainbridge	100	67	82.8	7.96	
Saticoy†				0.17		Pinkhamton	88	41	65.4	1.81		Blakely	96	70	79.8	12.52	
Shasta				T.		Redcliff				1.06		Brag†	104	68	82.4	4.09	
Shasta Springs†	94	44	68.2	0.10		Rico†	79	35	57.5	4.13		Brunswick†	99	65	80.8	4.39	
Sneddens Ranch				0.25		Riverbend	98	64	79.0			Camak	99	59	81.2	10.63	
S. E. Farallone L. H.				0.00		Rockyford†	98	54	75.2	2.07		Canton†				7.97	
Stanford University	93	41	68.6	T.		St. Cloud†				2.59		Clayton†	95	53	75.1	11.11	
Stockton	100	50	75.2	T.		San Luis†	94	39	64.8	3.16		Columbus†	98	60	81.4	10.35	
Summerdale†	89	48	69.2	0.38		Selbert†				2.23		Cordele	99	65	81.8	5.20	
Susanville†	99	54	77.4	0.20		Smoky Hill Mine†	87	44	62.4	3.56		Covington	99	59	80.0	7.24	
Sutter Creek	102	42	68.8	T.		Stamford	76	38	55.4	4.30		Dahlonega†	95	50	73.8	8.06	
Tecate Dam	108	42	68.9	0.00		Sulphur Springs†	92	33	61.9	2.33		Diamond†	93	49	74.8	11.31	
Tehama	111	72	90.5	0.00		Surface Creek†	96	42	69.2	0.80		Eastman	100	65	82.0	6.08	
Telton Ranch				0.00		Thon†	102	49	72.2	2.03		Elberton†	97	58	79.0	7.46	
Templeton	106	58	72.5	0.00		T. S. Ranch	93	51	73.8	0.85		Fleming†	103	65	82.5	4.56	
Trinidad L. H.				0.00		Vilas				0.07		Fort Gaines	102	65	82.0	9.94	
Truckee	96	46	68.6	0.15		Walnut†				2.28		Gainesville†	100	54	78.6	10.61	
Tulare				0.20		Wray†	97	56	75.1	1.13		Gillsville†	98	54	78.5	7.62	
Tulare C.	118	54	86.8	0.14		Yuma				2.59		Griffin†	98	62	81.2	8.90	
Turlock	114	44	81.1	0.06		Connecticut.						Hephzibah†	96	68	82.3	6.75	
Ukiah†	100	45	72.0	0.02		Bridgeport	90	56	72.2	3.45		Lagrange†	100	63	79.9	11.05	
Upper Lake	103	47	77.1	T.		Canton†	89	47	69.7	3.39		Lumpkin†	98	65	80.3	8.21	
Upper Mattole	101	50	66.8	0.00		Colchester	88	51	70.8	2.45		Macon†	99	64	82.1	6.16	
Vacaville	109	60	79.6	T.		Falls Village				6.67		Marietta	94	57	76.9	9.36	
Ventura†	82	43	64.4	0.20		Greenfield Hill				4.10		Marshallville†	96	68	82.0	12.56	
Volcano Springs	124	84	104.9	0.00		Hartford	89	56	72.5	2.40		Milledgeville†	98	62	80.6	7.69	
Walnut Creek	106	57	76.6	0.00		Lake Konomoc				3.61		Millen	105	67	83.4	2.44	
Washington	100	53	74.2	0.01		Middletown	92	55	73.5	2.72		Morgan†	100	65	81.4	4.55	
West Point				T.		New London†	88	55	70.9	3.64		Newman†	98	60	80.2	10.14	
Wheatland†	111	52	80.6	0.00		North Franklin				1.84		Point Peter	96	58	78.3	8.65	
Williams	107	63	85.3	T.		North Grosvenor Dale	88	49	69.9	2.18		Poulan†	102	65	81.7	7.62	
Willows	104	68	88.5	0.00		Norwalk	90	52	71.6	4.71		Quitman†	95	69	81.6	12.04	
Wilmington	82	60	71.1	0.00		Southampton	89	56	72.0	3.23		Ramsey†	95	58	77.8	5.14	
Wire Bridge	107	60	83.7	0.30		South Manchester				2.83		Rome†	97	59	79.5	5.80	
Yerba Buena L. H.				0.00		Storrs	89	52	70.2	3.22		Talbotton†	96	63	78.9	9.86	
Yreka†	104	45	74.5	0.73		Voluntown†	90	47	71.3	3.89		Thomasville†	98	70	81.5	6.70	
Yuba City	104	66	83.4	T.		Wallingford†				2.89		Toccoa†	96	56	78.1	13.10	
Engineers Quarters†				0.00		Waterbury	88	53	72.0	3.16		Union Point†	94	59	78.0	10.10	
Morse House†				0.00		West Cornwall†	87	49	69.0	4.69		Washington†	98	60	79.4	11.94	
Grass Valley†				0.00		West Simsbury				4.57		Waycross†	100	68	82.6	10.81	
Deep Creek†				0.00		Windsor	90	55	72.6	3.18		Waynesboro†	99	63	80.6	4.37	
Holcomb Creek†				0.00		Delaware.						West Point	98	64	82.1	8.51	
Squirrel Inn†				0.00		Dover†	90	58	76.2	4.75		Idaho.					
Green Valley†				0.00		Millford	94	56	78.1	3.80		American Falls†	102	46	73.0	0.79	
Tunnel No. 2†				0.00		Millsboro	92	53	77.0	6.59		Birch Creek	100	42	72.8	0.21	
Colorado.						Newark	92	54	75.9	2.61		Blackfoot†	98	43	68.0	0.75	
Alma†	73	32	52.2	2.87		Seaford†	92	56	76.0	7.50		Boise Barracks†	106	49	76.3	0.10	
Antlers	99	50	73.0	1.09		Wilmington†	99	57	80.0	3.03		Burnside†	90	47	67.3	1.49	
Boxelder				1.93		District of Columbia.						Chesterfield†	87	31	63.1	0.90	
Breckenridge†	81	32	56.6	3.10		Dist'g Reservoir	90	62	78.1	3.63		Coeur d'Alene	100	42	70.2		
Brush†	101	49	72.6			Receiving Reservoir	92	63	78.0	3.83		Corral	92	55	65.4	0.24	
Byers	98	39	60.4			West Washington	95	54	77.0	3.93		Dairy†	98	40	70.9	0.58	
Canyon†	95	52	74.0	2.95		Florida.						Downey†	98	39	60.0	0.47	
Capps				0.33		Amelia†	93	70	80.8	4.64		Fort Lemhi†	96	41	70.3	1.35	
Castlerock†	94	43	67.2	3.67		Archer†	98	68	81.6	5.13		Fort Sherman†	101	43	70.9	0.32	
Collbran				2.46		Bart											

MONTHLY WEATHER REVIEW.

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TABLE II.—Meteorological record of voluntary and other cooperating observers—Continued.

Stations.	Temperature. (Fahrenheit.)			Precipitation.		Stations.	Temperature. (Fahrenheit.)			Precipitation.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.		Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
Idaho—Cont'd.	°	°	°	Ins.	Ins.	Illinois—Cont'd.	°	°	°	Ins.	Ins.
Roseberry†	94	36	65.5	1.03		Tuscola†	96	48	75.1	6.85	
Salubria†	103	46	74.2	0.28		Walnut†	97	45	75.0	6.32	
Shoup†	102	43	74.2	0.88		Wheaton†	96	52	70.2	5.14	
Soldier†	94	37	67.8	0.92		Winnebago†	96	41	71.7	4.95	
Warren†	96	36	65.6	1.00		Zion†	96	41	70.6	4.05	
Yellow Jacket†				1.85		Indiana.					
Illinois.						Anderson†	92	47	73.4	9.16	
Albion†	98	57	78.1	4.89		Angola†	100	55	73.8	12.78	
Alexander†	97	46	70.9	7.50		Auburn†	94	49	72.9	9.87	
Ashton†	95	57	74.6	4.71		Bloomington†	98	54	77.0	7.78	
Atlanta†	104	50	71.0	12.14		Bluffton†	94	46	73.7	6.53	
Atwood†	100	46	75.0	5.00		Butler†	96	49	73.0	8.75	
Aurora†	100	46	75.0	13.52		Cambridge City†	92	52	72.0	12.20	
Beardstown†	94	47	73.8	6.08		Columbia City†	93	52	74.8	8.33	
Bloomington†	99	47	75.4	8.34		Columbus†	92	50	73.7	7.31	
Bushnell†	95	50	73.7	6.30		Connersville†	94	48	74.6	7.61	
Cambridge†	97	51	76.3	6.53		Delphi†	94	60	77.4	7.72	
Carlinville†				6.92		Edwardsville†	100	55	79.0	5.53	
Carlyle†		52	70.0	6.42		Evansville†	91	49	73.0	11.83	
Carrollton†	96	54	76.6	6.27		Farmland†	91	54	73.9	6.08	
Cattlin†	96	54	76.6	5.00		Greencastle†				5.00	
Cazenovia†	95	53	75.7	10.04		Greensburg†	96	43	73.5	6.48	
Charleston†	98	39	71.2	5.10		Hammond†	94	50	73.4	11.08	
Chemung†				4.27		Huntington†	94	53	77.8	4.00	
Chester†	98	58	76.1	6.00		Jasper†	97	52	77.9	10.75	
Cleare†	99	42	75.0	9.65		Jeffersonville†	95	50	74.5	5.75	
Clearecreek†	100	54	77.6	3.76		Knightstown†	95	50	75.7	9.17	
Cobden†				6.81		Kokomo†	96	53	78.3	6.80	
Cordova†	95	50	75.5	7.12		Lacoma†	95	43	74.5	10.73	
Decatur†	95	44	73.1	4.81		Lafayette†	92	50	73.0	7.04	
Dixon†	100	62	80.4	5.23		Logansport†	96	52	76.8	7.05	
Duquoin†	100	40	75.0	4.61		Madison†	96	52	77.5	4.64	
Dwight†	100	40	75.0	7.97		Marengo†	96	50	70.7	6.19	
East Peoria†	100	51	77.8	5.40		Marion†	96	50	73.8	7.69	
Effingham†	96	60	72.5			Mauzy†	92	55	79.3	2.88	
Evansville†	95	47	71.4	3.86		Mount Vernon†	100	49	73.7	8.06	
Fort Sheridan†	101	56	73.4	9.45		Northfield†	94	56	77.2	4.00	
Friendgrove†	95	40	74.0	5.96		Princeton†	99			6.72	
Galva†				5.09		Richmond†	95	50	73.6	8.35	
Glenwood†				2.26		Rockville†	97	54	77.8	4.66	
Grafton†	103	53	78.3	8.10		Scottsbluff†	98	54	76.8	4.61	
Greenville†	95	51	76.9	5.31		Seymour†	98	46	72.2	7.45	
Griggsville†	95	66	83.0	4.87		South Bend†	92	50	73.3	7.47	
Halliday†	95	56	77.0	4.87		Sunman†				8.83	
Havana†	98	60	77.7	2.30		Syracuse†	98	56	77.3	7.29	
Herrin†	98	53	76.1	4.15		Terre Haute†	96	49	75.7	11.90	
Hillsboro†	99	50	72.6	5.54		Tipton†	94	49	73.4	7.56	
Iron†	98	45	74.2	4.97		Valparaiso†	97	59	78.8	7.50	
Joliet†	97	56	78.0	6.06		Vevay†	100	50	77.0	5.44	
Jordan Grove†	98	50	71.4	7.31		Vincennes†	98	56	76.8	3.33	
Kankakee†	91	60	75.4			Washington†	94	50	75.2	7.43	
Kankakee†	96	41	72.2	3.84		Indian Territory.					1.34
Kishwaukee†	95	48	70.0	7.25		Eufaula†	108	61	84.9	3.34	
Knoxville†	95	52	77.3	7.80		Healdton†	108	63	85.0	1.66	
Laharpe†	95	40	69.6	5.06		Lehigh†	105	57	79.0	1.05	
Lanark†	94	41	74.0	7.18		Purcell†	105	63	85.8	0.35	
Lexington†				6.50		Tahlequah†				0.60	
Loami†	94	55	75.6	6.36		Tulsa†					7.60
Louisville†	96	57	78.4	4.38		Iowa.					
McLeansboro†	96	54	74.7	10.57		Adair†	98	52	74.2	9.10	
Martinsville†	96	45	74.0	7.02		Afton†	97	56	72.5	1.94	
Martinton†	106	56	82.6	3.80		Algona†	95	50	70.6	5.74	
Mascoutah†	99	65	77.4	10.07		Alta†	96	49	72.8	10.20	
Mattoon†	94	51	73.8	5.39		Amana†	97	49	73.0	9.96	
Minooka†	94	43	73.8	5.79		Ames†	96	44	73.2	7.14	
Monmouth†	94	48	74.9	5.98		Atlantic†	96	54	73.4	7.48	
Morrisonville†				3.96		Atlantic (near)†	96	43	69.6	7.30	
Mount Carmel†	94	50	74.2	8.14		Audubon†	95	51	73.0	8.15	
Mount Pulaski†	99	56	78.6	6.70		Beekman†	97	47	72.0	8.13	
Mount Vernon†	104	54	80.1	5.29		Beile Plaine†	100	47	73.6	6.63	
New Burnside†	96	56	79.0	8.07		Bonaparte†	97	47	71.8	7.16	
Olney†	95	43	73.0	4.48		Cedar Falls†	96	48	73.0	6.76	
Oregon†	93	51	73.4	5.32		Cedar Rapids†	95	55	74.0	10.40	
Oswego†	100	43	74.4	8.63		Centerville†	94	55	73.2	9.06	
Ottawa†	95	52	77.4	7.76		Chariton†	95	47	71.7	2.14	
Palestine†	105	49	78.3	8.39		Charles City†	95	50	73.7	6.63	
Paris†				8.90		Clarinda†	95	47	74.4	7.13	
Peoria†	99	53	78.2	7.02		Clinton†	97	47	74.0	7.10	
Peoria†	98	49	74.4	7.27		College Springs†	96	47	72.7	8.34	
Philo†	100	56	77.8	5.56		Corning†	95	47	72.7	5.19	
Plumhill†	95	50	74.6	6.86		Council Bluffs†	95	43	69.4	3.26	
Rantoul†	94	46	73.2	6.09		Cresco†	95	46	70.1	1.82	
Reynolds†	95	46	71.4	3.29		Decorah†	99	49	71.2	7.64	
Riley†	95	50	74.8	7.10		Delaware†	101	51	73.0	6.01	
Robinson†	95	48	73.6	4.36		Denison†	95	51	71.8	4.98	
Rockford†	98	64	76.5	7.82		Dows†	98	49	73.0	9.16	
Rose Hill†	98	43	73.8	6.55		Eldora†	99	42	71.8	4.93	
Round Grove†	96	50	76.2	9.61		Elkader†	98	47	71.9	5.46	
Rushville†	96	50	72.3	6.07		Fairfield†	98	44	71.6	4.95	
St. Charles†	98	64	79.5	6.88		Fayette†	97	51	74.2	6.35	
St. John†	98	43	72.0	7.98		Fonda†	94	50	69.9	1.90	
Scales Mound†	94	53	75.8	5.75		Forest City†	95	50	77.0	7.62	
Streator†	94	40	71.2	3.60		Fort Madison†	100	49	71.8	7.38	
Sycamore†	96	50	73.6	5.57		Galva†					
Tiskilwa†											
Iowa—Cont'd.	°	°	°	Ins.	Ins.	Kansas.					
Gardengrove†	96	49	72.2	9.69		Abilene†	100	59	78.7	8.44	
Glenwood†	97	50	74.3	6.87		Achilles†	108	61	73.7	0.94	
Grand Meadow†	92	50	68.9	4.50		Altoona†	99	62	77.4	5.70	
Greenfield†	97	52	73.5	11.93		Assaria†	97	54	78.2	5.60	
Grundy Center†	97	47	70.5	10.10		Atchison†	98	57	76.6	6.98	
Guthrie Center†	96	46	73.0	8.66		Augusta†	99	60	78.2	6.08	
Hampton†	96	48	71.4	4.80		Baker†	97	51	75.0	5.39	
Hawkeye†	94	54	72.6	10.44		Beloit†	101	57	77.2	5.91	
Hopeville†	99	48	73.0	6.14		Bellevue†	101	57	77.2	5.91	
Humboldt†	96	46	70.8	7.67		Blaine†	108	53	76.0	5.04	
Independence†	95	46	70.8	7.81		Campbell†	98	62	80.4	3.34	
Indianola†	98	51	75.0	7.04		Chanute†	99	53	78.4	5.02	
Iowa City†	93	50	72.8			Colby†	100	57	78.4	5.02	
Iowa Falls†	94	45	68.8	5.98		Coldwater†	96	58	78.2	1.50	
Keosauqua†	96	53	75.8	5.64		Collyer†	96	55	78.2	8.50	
Knoxville†	96	53	75.8	9.76		Columbus†	104	58	80.0	1.00	
Lansing†	97	46	72.4	1.64		Coolidge†	103	57	78.7	5.11	
Larrabee†	98	48	70.9	6.80		Cunningham†	98	62	78.8	4.12	
Leclaire†	97	50	72.0	4.15		Delphos†				2.65	
Lemars†	97	57	73.5	6.05		Downs†	103	55	75.1	3.97	
Lenox†	99	44	74.6	6.70		Dresden†	103	58	78.4	6.25	
Logan†	100	50	77.1	5.10		Effingham†	102	52	75.4	6.25	
Madrid†	104	50	77.1	5.73		Eldorado†	97	62	78.0	5.48	
Malvern†	96	45	73.0	8.32		Elgin†	100	58	77.2	5.18	
Maquoketa†	99	48	73.2	2.08		Ellinwood†					
Marshall†	94	42	70.4	8.18							
Mason City†	95	54	75.8	7.22							
Maxon†	96	46	72.4	9.24							
Mechanicsville†				7.55							
Millman†	98	46	69.3	10.97							
Monticello†	95	45	73.3	12.67							
Montezuma†	95	53	74.9	2.92							
Moor†	100	53	74.9	6.11							
Mount Pleasant†	96	56	74.9	6.95							
Mount Vernon†											

TABLE II.—Meteorological record of voluntary and other cooperating observers—Continued.

Stations.	Temperature. (Fahrenheit.)			Precipitation.		Stations.	Temperature. (Fahrenheit.)			Precipitation.		Stations.	Temperature. (Fahrenheit.)			Precipitation.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.		Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.		Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
Kansas—Cont'd.						Kentucky—Cont'd.						Maryland—Cont'd.					
Emporia†	96	60	77.9	3.75		Owenton†	95	55	76.2	8.41		Greatfalls*†	92	63	77.7	2.95	
Englewood†	102	59	80.1	4.58		Paducah†	103	61	82.2	3.51		Greenspring Furnace	94	55	74.8	4.83	
Eureka†	102	56	78.4	1.81		Paducah‡	96	54	77.3	3.58		Hagerstown†	96	55	77.0	6.08	
Fort Riley†	94	58	76.9	7.46		Pleasure Ridge Park†	102	58	80.6	2.76		Jewell†	92	57	76.4	3.75	
Fort Scott†	96	56	78.0	3.33		Princeton†				5.52		Johns Hopkins Hospital	95	59	77.2		
Frankfort	101	60	80.0	8.66		Pryorsburg				5.32		Laurel	99	55	76.4	7.89	
Garden City				3.35		Russellville†	97	55	78.6	5.32		Mardela Springs†	92	57	77.2	3.15	
Garfield				5.88		St. John†	94	55	76.4	5.00		New Market	94	54	78.0	3.87	
Gibson	98	56	74.9	2.86		Sandhook†				10.80		Princess Anne	91	51	75.6	6.49	
Girard*†	99	63	79.7	5.34		Shelby City*†	96	58	75.9	10.92		Sharpsburg	95	52	75.1	4.16	
Gove*†	98	58	78.0	3.03		Shelbyville†	99	54	77.8	12.32		Solomons†	93	62	78.9	4.51	
Grainfield*†	100	62	78.8	4.55		Southfork†				9.53		Sunnyside	91	40	68.0	15.27	
Grenola*†	98	60	78.3	5.50		Springfield†	95	54	75.4	7.88		Taneytown	96	53	76.8	4.85	
Halstead	98	56	76.4	4.73		Vanceburg†	95	52	73.2	5.70		Van Bibber	97	56	77.0	2.45	
Hays	100	58	79.6	1.64		Williamsburg†	98	57	76.6	9.23		Western Port	99	48	75.3	7.60	
Horton†	99	57	77.0	5.61		Louisiana.						Massachusetts.					
Hutchinson†	99	60	78.4	6.72		Abbeville	93	68	81.0	4.00		Adams	89	46	71.2		
Independence†	104	60	81.4	6.47		Alexandria†	102	61	83.6	2.22		Amherst	89	50	70.9	5.67	
Jaqua	102	54	78.2	2.24		Amite†	100	53	82.4	5.46		Amherst Ex. Station‡	91	50	71.3	4.96	
Lakin	107	56	82.2	1.70		Bastrop	104	59	82.6	T.		Andover*†		47	68.2	2.47	
Lawrence	98	53	77.1	6.15		Baton Rouge†	96	66	82.6	2.64		Ashland				2.88	
Lebo†	100	57	78.4	5.06		Cameron†	99	70	85.6	7.78		Attleboro				1.73	
Linn				4.92		Cheneyville†	99	60	82.3	0.92		Bedford	88	47	69.9	2.95	
Lyons	105	60	81.3	4.26		Clinton†	100	63	82.6	2.64		Beverly Farms	90	52	67.5	3.52	
Macksville†	102	57	79.2	7.42		Covington†	98	60	81.8	3.36		Bluehill (summit)	89	54	69.5	3.56	
McPherson†	96	59	77.9	5.80		Davis	102	53	82.2	T.		Bluehill (valley)	91	48	70.5	2.78	
Manhattan‡	101	57	78.6	5.39		Donaldsonville†	95	67	82.3	1.17		Boston‡				2.07	
Manhattan‡	107	57	81.4	5.43		Elm Hall	99	66	80.4	0.50		Brockton‡	93	53	71.6	1.57	
Marion†	103	58	80.9	1.95		Emilio†	96	67	82.0	1.83		Brockton‡				1.53	
Meade†	104	55	78.2	2.53		Farmerville	102	60	84.8	T.		Brockton‡				1.45	
Medicine Lodge†	106	60	80.6	5.47		Franklin	96	69	83.0	4.64		Cambridge‡	93	51	72.4	2.87	
Minneapolis†	100	59	78.7	6.06		Grand Coteau	95	68	81.8	4.62		Chestnut Hill	94	50	72.6	3.00	
Morantown†	96	59	78.0	4.39		Hammond†	99	64	81.3	4.92		Clinton				3.25	
Morland	100	50	75.3	3.02		Houma†				4.30		Cohasset				2.59	
Morton†	106	57	81.2	0.90		Jeanerette†	99	70	83.8	4.19		Dudley†	90	51	70.7	5.10	
Mounthope*†	99	62	79.7	6.01		Lafayette†	99	67	82.4	1.97		East Templeton*†	88	57	70.2	2.99	
Ness City†	105	58	80.5	4.22		Lake Charles*†	97	69	83.2	4.92		Egg Rock Nahant	87	55	67.2		
New England Ranch†	100†	48†	76.3†	4.99		Lake Providence	104	69	86.6	0.00		Fallriver	90	59	71.8	4.42	
Norton†	97	50	72.3	1.39		Lawrence	99	71	84.6	1.40		Fitchburg‡	88	57	70.4	2.57	
Norwich	100	58	82.0	4.83		Liberty Hill	109	58	87.0	T.		Fitchburg‡	91	51	71.2	2.72	
Oberlin†				2.82		Mansfield†	101	59	83.3	0.63		Framingham	93	50	72.4	2.14	
Olathe†	100	55	78.4	5.82		Maurepas	102			1.09		Groton	89	46	70.1	3.04	
Osage City†	102	57	78.4	5.88		Melville†	97	64	82.4	0.90		Hobbs Brook				2.12	
Oswego†	100	57	81.2	5.96		Minden	103	64	85.4	0.00		Hyannis*†	92	58	73.5	4.35	
Ottawa†	98	57	76.1	4.82		Monroe†	101	66	86.0	0.00		Lake Cochituate	94	48	72.1	2.22	
Paola†	100	53	77.8	4.00		New Iberia	94	72	82.2	4.40		Lawrence	93	52	73.2	3.32	
Phillipsburg†	100	56	75.8	5.08		Oakridge†	109†	57	83.8	0.40		Leeds	90	48	70.8	4.72	
Pleasant Dale†	102	57	78.6	3.51		Opelousas†	99	65	82.3	3.20		Leicester Hill	89	48	69.8	4.88	
Pratt†	97	58	76.7	5.58		Oxford†	100	58	82.6	1.11		Leominster				3.25	
Rome*†	96	61	77.7	4.93		Plain Dealing†	102	62	85.2	0.65		Long Plain*†	88	54	70.9	4.38	
Russell†	102	54	78.4	3.44		Rayne†	100	68	83.1	3.58		Lowell‡	92	52	72.0	3.79	
Salina†	100	57	79.0	6.16		Robeline†	101	59	83.5	1.13		Lowell‡	95	53	72.8		
Scott City†	99	57	75.8	3.07		Schriever†	98	66	82.4	4.02		Ludlow Center	88	46	67.3	5.73	
Sedan†	100	60	79.7	4.54		Shellbeach	96	72	80.4	4.89		Mansfield*†	92	50	71.0	1.91	
Sharon Springs*†	105†	60†	78.0†	2.12		Southern University†	94	68	80.1	3.66		Middleboro	89	47	70.6	2.01	
Tribune†	99†	57†	77.2†	0.90		Sugar Ex. Station†	97	70	83.0	4.44		Milton	90	49	69.2	2.50	
Ulysses†	108	59†	81.6†	0.83		Sugartown	98	68	86.2	0.41		Monroe	87	41	65.7	5.78	
Wakefield*†	100	62	78.8	10.95		Thibodeaux				1.82		Monson	91	51	71.4	4.85	
Wallace*†	102	64	75.8	4.48		Venice†	97	62	84.0	5.46		Mount Nonotuck				4.62	
Wamego*†	100	60	78.6	5.98		Wallace	95	69	82.2	1.72		Mount Wachusett				4.70	
Wellington*†	98	62	78.8	4.04		West End				1.78		Mystic Lake				2.45	
Winfield*†	108	60	81.4	3.63		White Sulphur Springs	98			0.95		Mystic Station				2.53	
Winona				2.50		Maine.						Natick*†	88	59	70.9	2.06	
Yates Center†	96	58	77.6	5.71		Bar Harbor	89	48	66.2	6.05		New Bedford‡	86	53	69.6	2.90	
Kentucky.						Belfast*†	85	50	66.9	5.19		New Bedford‡	89	50	71.0	2.58	
Alpha†	94	57	77.9	10.25		Cornish*†	90	52	69.5	4.30		North Billerica	90	47	70.3	2.95	
Bardstown†	95	59	76.7	5.48		Cumberland Mills	97	47	72.2	3.42		Pittsfield	87	50	70.3	4.15	
Blandville†	97	56	77.9	4.11		Fairfield	89	43	66.9	3.21		Princeton				5.10	
Bowling Green‡	97	56	73.8	7.96		Farmington†	96	51	72.4	3.75		Provincetown	87	54	70.1		
Bowling Green‡	99	59	79.1	8.21		Flagstaff†	89	40	64.4†	4.85		Quinapoxet				4.78	
Burnside†				8.06		Fort Fairfield	91	47	66.4†	4.05		Roberts Dam				2.67	
Caddo†	94	54	75.0	7.85		Gardiner	93	52	70.2	3.18		Roxbury	90	52	70.4	2.60	
Canton*†	99	62	78.3	2.91		Kineo†	85	49	66.3	4.02		Salem				2.73	
Carrollton†	99	54	79.0	5.06		Lewiston	96	54	70.7	3.08		Somerset*†	96	57	75.0	2.74	
Catlettsburg*†	96	64	78.5	6.60		Mayfield	91	46	66.8	6.07		South Clinton				4.83	
Earlington	97	59	79.0	5.06		North Bridgton	91	50	69.0	3.54		Springfield Armory	93	51	71.4	5.74	
Edmonton†	92†	57†	77.4†	8.27		Petit Menan*†											

TABLE II.—Meteorological record of voluntary and other cooperating observers—Continued.

Stations.	Temperature. (Fahrenheit.)			Precipitation.		Stations.	Temperature. (Fahrenheit.)			Precipitation.		Stations.	Temperature. (Fahrenheit.)			Precipitation.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.		Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.		Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
Michigan—Cont'd.						Minnesota—Cont'd.						Mississippi—Cont'd.					
Arbela.....	94	42	71.2	2.21		Bird Island.....	93	50	68.2	2.60		Pontotoc.....	103	61	83.0	2.39	
Bad Axe.....	94	42	68.1	1.05		Blooming Prairie†.....	95	44	69.4	0.87		Port Gibson.....	102	59	83.4	1.16	
Ball Mountain.....	89	47	69.6	4.61		Bonniwell.....	95	48	70.3	1.14		Rosedale†.....	101	65	84.0	1.22	
Baraga.....	98	42	66.5	1.30		Breese.....	94	36	65.8	1.70		Stonington*.....	102	70	84.0		
Battlecreek.....	95	50	72.6	7.55		Caledonia.....	95	47	70.4	2.43		Thornton.....	99	65	84.7	0.30	
Bay City.....	92	48	70.5	2.10		Cambridge.....	92	40	66.2	0.33		Topton*.....	98	70	82.4	0.80	
Bay City.....	94	48	70.7	0.74		Camden.....	99	46	68.2	0.77		University.....	97	64	81.2	0.95	
Benton Harbor.....	98	46	71.0	4.63		Clear Lake.....	92	44	68.0	1.72		Water Valley*.....	107	60	81.7	1.42	
Berlin*.....	96	51	71.9	3.81		Collegeville.....	98	51	70.9	2.37		Waynesboro.....	103	61	81.7	2.80	
Berrien Springs.....	95	45	71.6	4.55		Crookston.....	94	46	67.6	1.05		Waynesboro.....	100	62	82.0	3.52	
Big Rapids.....	91	43	68.9	1.06		Dawson.....	100*	49	68.9	0.99		Williamsburg.....	103	68	82.8	1.70	
Birmingham.....	92	47	72.8	6.05		Detroit City.....	96	45	69.2	2.09		Windham.....	105	62	82.0	3.29	
Bois Blanc*.....	92	52	70.3			Faribault.....	96	44	70.2	0.77		Woodville.....	99	65	82.2	5.13	
Boon.....	90	41*	66.9	2.06		Farmington.....	94	44	69.3	1.98		Yazoo City.....	105	58	86.0	0.59	
Bronson.....	96	47	72.2	7.30		Fergus Falls.....	90	49	68.8	5.33		Missouri.					
Calumet.....	87	45	64.6	1.76		Glenwood.....	100	47	70.4	1.90		Akron.....				7.98	
Charlevoix.....	92	41	64.6	1.30		Grand Meadow.....	97	45	70.6	2.15		Arthur*.....	62	77.9	3.15		
Cheboygan.....	92	44	66.5	1.97		Granite Falls.....	96	45	68.6	2.85		Bethany.....	96	53	75.6	6.74	
Clinton.....	92	43	72.9	6.30		Lakeside.....	93	46	69.3	3.00		Birchtree.....	100	52	77.6	2.42	
Pitchburg.....	98	40	71.4	5.04		Lake Winnibigoshish.....	90*	50	66.4	1.81		Bolckow.....				6.04	
Flint.....	95	43	70.5	2.20		Lambert.....	92	40	66.6	0.68		Boonville.....				3.42	
Gaylord.....	89	39	66.0	1.19		Lawrence.....	92	42	66.7	1.50		Brunswick.....	94	50	76.0	7.27	
Gladwin.....	90	40	69.0	1.93		Leech Lake.....	90*	43	66.4	2.21		Carrollton.....	96	57	77.6	5.57	
Grand Rapids.....	91	47	71.8	3.66		Lesueur.....	100	52	74.2	0.50		Cedarap.....	98	60	77.6	1.91	
Grape.....	92	45	72.0	4.74		Long Prairie.....	95	42	68.1	2.61		Conception.....	92	56	74.2	5.95	
Grayling.....	95	36	67.3	1.06		Luverne.....	96	47	69.1	1.90		Cowdell.....	100	60	79.0	7.22	
Hanover.....	91	44	70.2	8.88		Mapleplain.....	95	44	70.3	0.75		Darksville.....	99	55	77.0	4.82	
Harrison.....	93	39	68.6	1.99		Maplewood*.....	92	57*	71.0*		Downing.....				14.98		
Harrisville.....	99	46	66.0	2.56		Mazeppa.....	95*	38	72.2	0.90		East Lynne*.....	56	74.4	4.85		
Hart.....	95	40	69.1	1.50		Millan.....	94	43	68.2	3.92		Edgehill*.....	94	66	77.8	5.26	
Hastings.....	88	48	70.4	5.52		Minneapolis.....	94	47	71.0	1.73		Eightmile*.....	98	57	74.9	5.35	
Hayes.....	95	45	70.8	0.67		Minneapolis.....	94*	43	69.8	1.15		Eldon*.....	98	56	76.6	6.68	
Hesperia.....	95	38	71.2	1.04		Minnesota City.....	96	46	70.9	1.13		Elmira.....	104	49	77.6	9.34	
Highland Station.....				6.75		Montevideo.....	92	45	69.0	2.62		Emma.....				3.97	
Holland*.....	84	51	69.4			Morris.....	92	45	69.2	2.06		Fairport.....				8.14	
Howell.....	94	39	70.7	7.23		Mount Iron.....	89	40	64.3	4.39		Farmersville.....				4.60	
Iron River.....	89	35*	62.4*	1.82		New Richmond*.....	93	55	67.4			Fayette.....	96	55	76.8	7.02	
Ivan.....	94	40	69.0	1.40		New Ulm.....	96	50	71.2	0.83		Fulton.....				7.90	
Jeddo.....	92	43	68.8	2.15		Park Rapids.....	94	41	67.4	1.59		Gallatin*.....	96	57	75.2	8.62	
Lake City.....	95*	45*	70.9*	1.29		Pine River.....	89	54	67.6	2.46		Gayoso*.....		62	78.1	3.68	
Lansing.....	90	43	69.7	7.10		Pleasant Mounds.....	96	47	69.4	1.30		Glasgow.....	97	53	76.4	3.89	
Lathrop.....	95	33	64.4	2.68		Pokagon Falls.....	91*	38	66.0	2.39		Gordonville*.....		59	75.1	2.11	
Lewiston.....	89	41	66.2	3.10		Redwing.....				1.31		Gorin*.....	102	55	75.8	12.37	
Ludington*.....	86	45	71.5			Reeds.....				0.71		Grovedale.....	108	49	80.5	4.41	
Luzerne.....		39		1.39		Roseau.....	89	37	62.0	0.62		Halfway.....	96	52	77.0	3.04	
Mackinaw City.....	87	44	65.7	2.34		St. Charles.....	96	44	69.3	1.67		Harrisonville.....	97	56	77.0	3.60	
Madison.....	93	48	72.2	3.84		St. Cloud.....	90	45	68.1	2.32		Herrmann.....				6.37	
Manistiquie.....	85	41	68.4	2.94		St. Olaf.....	90	48	68.2	3.58		Houston.....	100	48	76.4	2.36	
Mancelona.....	91	39	68.0	1.20		Sandy Lake Dam.....	87*	43	66.2	2.24		Houstonia (near).....				4.27	
Mayville.....	94	48	70.7	1.98		Sank Center.....	95	46	67.0	1.70		Irena.....				5.83	
Middle Island*.....	90	56	69.4			Shakopee.....	95*	48	71.4	0.62		Ironton.....	99	52	76.3	6.39	
Midland.....	95	42	71.2	0.86		Tower.....	94	38	64.8	4.20		Jefferson City.....	98	59	79.0	5.55	
Mottville.....	94	46	72.1	7.40		Two Harbors.....	86	45	63.3	3.27		Kidder.....	100	54	76.0	5.80	
Mount Pleasant.....	93	41	70.4	1.27		Wabasha*.....	92	52	70.3	0.93		Lamar.....	96	56	78.8	5.59	
Mount Pleasant.....	96	42	70.5	1.15		Willmar.....	92	45	68.6	0.97		Lamonte.....				5.52	
Muskegon.....	86	50	69.3	3.47		Winona.....	94	53	71.5	1.83		Lebanon.....	96	55	77.4	5.73	
North Manitou Island*.....	85	50	67.2			Worthington.....	94	44	68.8	3.56		Lexington.....	97	53	76.9	5.06	
North Marshall.....	89	48	68.9	7.01		Zumbrota.....	94*	37	71.4			Liberty.....	99	55	78.4	7.28	
Northport.....	88	45	66.4	0.60		Mississippi.						McCune*.....	99	56	77.6	9.83	
Old Mission.....	91	45	69.7	0.84		Aberdeen.....	104	57	83.6	2.60		Macomb.....				2.00	
Olivet.....	89	48	70.8	8.82		Agricultural College.....	101	62	82.6	2.60		Mansfield.....				2.61	
Ovid.....	95	44	72.0	3.24		Austin.....	99	62	83.7	0.16		Marblehill.....	99	53	78.0	6.89	
Owosso.....	94	42	69.9	3.47		Batesville.....	101	57	81.8	0.60		Marcelline.....	100	50	76.4*	6.51	
Parkville.....				6.19		Bay St. Louis.....	99	62	82.2	4.55		Marshall.....	104	50	78.2	3.75	
Petoskey.....	86	44	65.7	1.66		Biloxi.....	99	72	81.0	3.87		Maryville.....	98	51	75.0	3.95	
Plymouth.....	94	45	71.2	6.48		Booneville.....	99	58	81.0	4.82		Mexico.....	99	51	77.6	6.43	
Pontiac.....	90	46	69.0	7.28		Brierley.....	98	68	82.8	0.95		Mine La Motte.....	94	52	76.0	6.33	
Port Austin.....	98	42	68.1	0.79		Brookhaven.....	105	60	83.7	1.45		Mineralspring.....	97	53	77.8	1.51	
Powers.....	91	32	64.6	1.97		Canton.....	101	61	83.4	1.32		Montreal*.....	96	62	75.8	3.76	
Reed City.....	94	34	69.2	1.74		Columbus.....				2.45		Mount Vernon.....	100	48	76.3	2.45	
Rockland.....	90*	45*	66.7*	1.35		Columbus.....				1.55		Neosho.....	94	53	78.3	3.51	
Rogers City.....	88	43	65.0	1.70		Corinth.....	101	50	77.8	3.36		Nevada.....				3.43	
Saginaw.....	93			1.22		Crystal Springs.....	103	64	84.2	3.16		New Haven*.....	96	64	81.1	6.08	
St. Ignace.....	83	45	64.9	2.20		Edwards.....	103	65	85.8	0.95		New Madrid.....	100	60	82.4	6.51	
St. Johns.....	94																

Stations.	Temperature. (Fahrenheit.)			Precipitation.		Stations.	Temperature. (Fahrenheit.)			Precipitation.		Stations.	Temperature. (Fahrenheit.)			Precipitation.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.		Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.		Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
Missouri—Cont'd.						Nebraska—Cont'd.						Nevada—Cont'd.					
Stelladaf.....	102	54	77.2	5.89		Greeley.....	102	54	77.2	5.89		Crane Ranch.....	102	54	77.2	5.89	
Sublett.....	97	51	73.6	9.90		Haigley.....	97	51	73.6	9.90		Elko.....	95	36	66.6	0.79	
Trenton.....	97	55	77.0	4.17		Hartington.....	98	58	75.1	5.56		Ely.....	101	42	70.8	0.15	
Unionville.....	99	51	74.6	9.04		Harvard.....	98	58	75.1	3.19		Fenelon.....	102	58	76.4	0.00	
Virgil City.....	96	54	77.4	4.94		Hastings.....	98	54	74.4	3.50		Golconda.....	106	47	71.0	0.14	
Warrenton.....	103	52	77.4	2.64		Hay Center.....	101	51	71.7	1.64		Halleck.....	97	62	78.0	0.82	
Wheatland.....	104	56	83.4	3.13		Hebron.....	96	55	74.2	4.63		Hawthorne.....	100	48	70.2	0.82	
Willow Springs.....						Hickman.....						Hot Springs.....	97	56	76.8	T.	
Zeltonia.....						Holdrege.....						Knickerbocker Mill.....	92	45	68.9	2.44	
Montana.						Nebraska—Cont'd.						Nevada—Cont'd.					
Agricultural College.....	94	41	66.0	0.92		Holdrege.....	100	50	76.1	3.10		Los Vegas.....	96	56	78.6	0.61	
Augusta.....	96	38	66.5	1.60		Imperial.....	103	53	74.5	3.15		Lewers Ranch.....	95	42	69.5	0.58	
Bigtimber.....	97	42	70.8	1.34		Indianola.....						Mill City.....	106	70	82.6	0.12	
Billings.....	101	48	74.2	0.81		Indianola (near).....	94	59	75.1	1.05		Palmetto.....	105	52	77.0	0.80	
Bozeman.....	92	43	66.6	1.15		Kearney.....	98	60	77.3	3.49		Osceola.....	96	47	72.0	0.75	
Butte.....	90	42	65.2	1.19		Kennedy.....	103	55	75.2	4.89		Palmetto.....	105	51	80.0	0.00	
Chinook.....	102	44	73.2	1.11		Kimball.....	97	51	72.8	2.43		Reno.....	99	39	70.8	1.03	
Choteau.....	99	39	67.0	1.07		Kirkwood.....	100	52	71.7	3.08		Saint Clair.....	97	48	71.5	0.52	
Cokedale.....	97	39	65.3	0.82		Lexington.....	94	44	72.2	2.37		Saint Thomas.....	112	55	88.9	0.25	
Columbia Falls.....	99	38	71.6	0.51		Lincoln.....	95	57	74.4	5.63		Sodaville.....	105	43	73.2	2.30	
Dillon.....	92	36	62.6	1.15		Lincoln.....	95	53	75.0	5.33		Stofield.....	105	47	75.8	0.91	
Fort Custer.....	104	39	74.2	4.05		Lincoln.....	97	53	75.0	3.76		Sunny.....	105	30	65.0	1.71	
Fort Keogh.....	100	40	73.0	0.81		Lodgepole.....	98	52	71.4	3.01		Tecoma.....	105	57	76.2	.....
Fort Logan.....	91	34	63.8	2.90		Loup.....	100	56	73.7	3.86		Tybo.....	103	42	69.5	2.10	
Fort Missoula.....	97	42	67.6	0.58		Lynch.....	100	55	73.0	4.76		Verdi.....	105	45	71.9	1.11	
Glasgow.....	102	36	72.0	1.13		Lyons.....	101			8.98		Wadsworth.....	104	60	76.0	2.04	
Glendive.....	103	50	72.8	1.53		McCook.....	99	62	80.3	0.83		Wells.....	97	44	70.0	0.10	
Great Falls.....	100	40	71.0	0.65		McCool.....				3.96		New Hampshire.					
Kalspell.....	90	42	67.8	0.73		Madison.....	99	50	70.6	3.15							

MONTHLY WEATHER REVIEW.

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TABLE II.—Meteorological record of voluntary and other cooperating observers—Continued.

TABLE II.—Meteorological record of voluntary and other cooperating observers—Continued.											Temperature. (Fahrenheit.)		Precipitation.				
Stations.	Temperature. (Fahrenheit.)			Precipitation. Rain and melted snow.	Total depth of snow.	Stations.	Temperature. (Fahrenheit.)			Precipitation. Rain and melted snow.	Total depth of snow.	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.	
	Maximum.	Minimum.	Mean.				Maximum.	Minimum.	Mean.								
New Jersey—Cont'd.						New York—Cont'd.						North Carolina—Cont'd.					
Paterson	91	56	74.6	4.88		Lockport	94	52	73.2	6.50		Springhope	96	63	78.7	3.40	
Perth Amboy	92	55	74.9	7.05		Lowville	91	44	69.2	3.50		Tarboro	103	61	80.6	4.71	
Plainfield	92	55	74.9	3.02		Madison Barracks	87	49	69.1	4.02		Waynesville	87	47	70.8	12.05	
Rancocas	94	66	78.9	4.48		Malone	87	47	67.6	5.71		Weldon	99	63	80.0	9.02	
Readington	92	49	72.5	4.48		Manhattan Beach	95	59	71.3	3.59		Wilkesboro	97	52	74.4	9.85	
Rivervale	94	66	78.9	4.48		Middletown	85	52	71.6	5.07		Wilmington	96	62	78.6	7.42	
Sergeantsville	95	51	76.1	7.09		Mohawk Lake	95	50	67.0	4.32		North Dakota.					
Somerville	90	55	74.0	7.95		Mount Morris	96	45	73.3	4.91		Amenia	97	45	68.3	0.82	
South Orange	94	50	76.0	2.86		Newark Valley	89	43	66.7	5.12		Ashley	100	36	64.8	1.47	
Staffordville	95	62	79.2	5.56		New Lisbon	90	52	70.7	2.49		Bottineau	90	44	66.1	1.71	
Toms River	95	62	79.2	5.56		North Hammond	85	43	65.0	7.05		Buxton	102	42	67.2	0.77	
Trenton	94	53	77.0	3.31		Number Four	87	48	71.2	7.02		Churches Ferry	100	40	67.6	1.27	
Vineland	90	50	73.6	5.32		Ogdensburg	93	48	71.2	7.02		Coalharbor	102	36	67.2	2.32	
Woodbine	90	50	73.6	5.32		Oneonta	92	44	69.6	5.37		Dickinson	97	36	67.2	1.48	
New Mexico.						Oxford	92	48	69.9	5.07		Ellendale	106	36	68.2	1.91	
Albuquerque	93	58	76.3	1.98		Palermo	92	48	69.9	5.07		Falconer	95	40	67.7	0.91	
Alma	96	56	75.5	1.70		Perry City	93	51	70.1	4.18		Fargo	97	41	67.7	1.75	
Aztec	95	49	73.9	1.02		Pittsford	91	48	70.4	5.04		Forman	101	40	73.2	1.60	
Bernalillo	94	50	72.6	0.80		Plattsburg Barracks	95	50	69.0	5.00		Fort Berthold	105	44	70.8	1.76	
Bluewater	94	42	66.9	2.63		Port Jervis	89	51	72.2	8.71		Fort Yates	100	40	67.0	2.41	
Chama	95	59	74.6	2.68		Potomac	88	47	67.8	3.13		Gallatin	96	37	65.8	0.90	
Clayton	98	68	82.4	4.30		Poughkeepsie	91	46	72.5	3.33		Grafton	98	40	66.4	1.27	
Deming	95	59	74.6	2.68		Ridgeway	96	46	70.3	6.04		Grand Rapids	94	49	69.2	2.49	
East Las Vegas	96	57	78.4	1.02		Rome	92	51	71.5	4.92		Jamestown	97	40	69.0	1.08	
Eddy	94	62	76.2	2.84		Romulus	90	40	66.8	4.19		Kelso	92	40	64.4	1.71	
Engle	93	48	72.0	1.36		Rose	90	40	66.8	4.19		Langdon	93	36	65.6	1.41	
Espanola	90	48	70.6	7.25		Saranac Lake	88	56	72.8	2.74		McKinney	107	41	71.4	0.93	
Fort Bayard	98	47	71.2	1.94		Scottsville	88	56	72.8	2.74		Medora	97	42	66.2	1.75	
Fort Wingate	100	56	73.9	4.21		Setauket	88	41	67.4	4.98		Milton	103	43	68.7	0.47	
Gallatin	97	52	75.2	3.46		Sherwood	88	41	67.4	4.98		Minto	104	41	68.3	1.23	
Gallinas Spring	100	58	78.9	4.93		Skaneateles	88	41	67.4	4.98		Napoleon	100	42	71.0	1.90	
Gila	101	55	76.0	3.01		South Canisteo	91	42	68.0	5.50		New England City	95	43	68.4	0.67	
Hillsboro	77	34	56.6	5.05		South Reservoir	91	42	68.0	5.50		Oakdale	104	41	69.9	1.74	
Labelle	98	57	76.2	2.50		South Kortright	94	44	69.8	5.71		Porter	96	45	68.0	1.50	
Las Cruces	95	65	80.4	1.91		Tyrone	94	44	69.8	5.71		Power	92	42	65.8	1.24	
Lordsburg	94	50	72.5	1.65		Varysburg	95	45	72.9	4.14		St. John	100	39	67.2	1.35	
Los Lunas	90	50	70.7	3.56		Victor	92	45	74.4	5.40		Shenando	103	42	68.1	2.66	
Lower Penasco	98	40	65.5	8.15		Wappingers Falls	94	45	68.8	3.71		Steele	103	40	65.8	0.82	
Monero	96	45	66.0	3.15		Warwick	94	45	68.8	3.71		Towner	90	45	68.0	0.60	
Ocate	100	54	77.6	0.78		Watertown	98	45	71.0	5.81		University	92	36	62.4	2.29	
Ohio	100	60	79.2	2.13		Waverly	92	50	71.6	3.09		Valley City	98	47	68.0	4.78	
Puerto de Luna	100	60	79.2	2.13		Wedgwood	90	50	71.6	3.09		Wahpeton	98	47	66.2	1.74	
Raton	104	45	69.1	1.08		Westfield	93	51	73.3	2.50		Wildrice	99	39	66.5	1.44	
Rincon	104	45	69.1	1.08		Westpoint	93	51	73.3	2.50		Willow City	91	41	63.0	1.07	
Roswell	98	57	76.0	1.29		Willetsport	92	57	73.2	5.79		Ohio.					
San Marcial	96	58	69.3	5.84		North Carolina.						Akron	90	50	71.7	8.40	
Shattucks Ranch	94	58	76.1	3.00		Ashville	91	67	79.2	7.62		Annapolis	94	40	71.0	8.78	
Socorro	90	50	72.0	2.12		Beaufort	90	48	73.4	9.03		Ashland	88	48	70.9	7.20	
Springer	84	50	65.7	5.83		Biltmore	99	62	79.8	10.30		Ashtabula	90	53	71.0	4.37	
Valley Ranch	90	52	70.3	2.01		Bryson City	99	62	79.8	10.30		Athens	98	50	74.1	7.23	
White Oaks	90	52	70.3	2.01		Chapel Hill	94	64	79.5	5.60		Atwater	90	43	70.0	4.69	
Winsors Ranch	90	52	70.3	2.01		Edenton	98	63	80.1	5.25		Auburn	94	55	72.3	9.44	
New York.						Experimental Farm	98	63	80.1	5.25		Bangorville	98	45	75.2	6.32	
Adams	89	47	70.0	4.45		Fairbluff	97	68	80.0	4.10		Basil	98	45	75.2	6.32	
Addison	89	47	70.0	4.45		Falkland	99	63	79.6	5.52		Bellefontaine	98	45	75.2	6.32	
Akron	89	46	67.4	4.46		Fayetteville	90	45	72.5	13.77		Bement	94	45	73.2	8.13	
Alfred	89	46	67.4	4.46		Flatrock	100	64	81.0	5.06		Benton Ridge	98	47	73.2	8.13	
Angelica	89	46	67.4	4.46		Goldsboro	94	62	77.2	9.55		Berlin Heights	97	52	76.1	6.79	
Appleton	89	46	67.4	4.46		Greensboro	94	62	77.2	9.55		Bethany	92	45	71.7	8.00	
Arcade	95	46	72.0	4.87		Henderson	84	44	67.6	8.56		Big Prairie	94	53	75.6	7.50	
Avon	92	54	72.6	4.34		Highlands	90	45	72.6	11.58		Bisolia	98	45	75.2	6.32	
Baldwinsville	89	52	71.7	7.29		Horse Cove	90	45	72.6	11.58		Bissells	93	45	71.6	8.56	
Bedford	88	55	69.4	3.85		Jacksonville	92	52	74.4	8.83		Bladenburg	92	49	72.7	8.12	
Big Sandy	93	47	71.0	5.82		Jefferson	91	56	74.4	7.85		Bloomington	95	45	71.4	8.23	
Binghamton	93	47	71.0	5.82		Lenoir	82	45	67.3	11.74		Bowling Green	92	45	71.6	12.72	
Bloomville	86	41	67.0	7.75		Linville	100	50	78.5	7.12		Cambridge	95	52	76.4	7.24	
Bolivar	94	48	73.6	4.70		Littleton	98	61	79.6	7.22		Camp Dennison	94	47	72.2	10.07	
Boys Corners	94	48	73.6	4.70		Louisburg	101	65	82.4	4.81		Canal Dover	94	47	72.2	10.07	
Brentwood	93	47	72.2	4.23		Lumberton	92	65	73.9	9.87		Canfield	91	48	72.3	8.43	
Brookfield	91	58	75.5	3.25		Lynn	94	54	75.1	7.38		Canton	92	43	69.9	9.05	
Brooklyn	90	42	68.8	3.54		Marion	99	60	78.2	7.17		Carrollton	92	43	69.9	9.05	
Canton	91	53	73.8	5.09		Mocksville	98	62	79.4	9.21		Cedarville	98	51	73.6	7.22	
Carmel	91	53	73.8	5.09		Monroe	95	61	78.2	9.21		Celina	100	46	76.8	8.32	
Catskill	89	54	68.0	5.22													

TABLE II.—Meteorological record of voluntary and other cooperating observers—Continued.

Stations.	Temperature. (Fahrenheit.)			Precipitation.		Stations.	Temperature. (Fahrenheit.)			Precipitation.		Stations.	Temperature. (Fahrenheit.)			Precipitation.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.		Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.		Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
Ohio—Cont'd.						Oklahoma—Cont'd.						Pennsylvania—Cont'd.					
Greenhill	93	44	71.0		Ins.	Mangum	102	60	81.1	4.97		Emporium	87	45	69.7		Ins.
Greenville	89	50	71.8			Normant	107	62	84.8	2.12		Farrandsville	87	45	69.7		5.11
Hackney	95	53	74.1		10.37	Ponca	101	60	82.1	3.49		Forks of Neahaminy	89	64	76.1		5.08
Hanging Rock	96	51	70.2		7.30	Pondoreck	107	59	81.4	5.09		Frederick	87	45	69.7		4.02
Hedges	94	42	72.0		5.41	Prudence	103	60	81.8	5.77		Freeport	87	45	69.7		7.74
Hillhouse	92	45	70.0		6.88	Sac and Fox Agency	103	56	80.1	2.50		Girardville	87	45	69.7		7.79
Hillsboro	97	48	76.6		5.14	Stillwater	99	59	80.0	5.85		Gramplan	90	50	71.6		11.80
Hiram	89	54	70.8		4.57	Winnview	104	61	81.4	6.14		Greensboro	87	45	69.7		8.83
Hudson	98	54	75.0		7.07	Woodward	105	70	86.0	1.70		Hamburg	87	45	69.7		12.72
Jacksonboro	97	52	74.8		4.75							Hollidaysburg	87	45	69.7		6.00
Kenton	94	48	73.6		7.30							Huntingdon	94	46	72.0		7.10
Killbuck	89	46	71.1		9.18							Huntingdon	94	46	72.0		4.63
Lancaster	92	48	73.5		10.12							Johnstown	94	50	73.2		3.60
Leipsic	96	44	72.8		7.47							Karhaus	87	45	69.7		8.45
Levering	92	40	70.7		8.90							Keating	87	45	69.7		4.94
Logan	96	46	74.7		7.32							Kennett Square	92	54	75.2		6.81
Lordstown	90	47	69.8		6.73							Lancaster	93	55	74.7		4.44
Lowell	94	48	72.8		9.94							Lansdale	91	51	73.8		5.40
McArthur	94	48	72.8		8.52							Lebanon	91	51	73.8		6.28
McConnelsville	94	48	74.0		8.89							Leroy	90	50	70.4		5.84
Marletta	95	50	73.6		7.77							Lewisburg	93	50	72.8		5.62
Marletta	95	50	73.6		7.77							Lock Haven	95	50	74.4		5.75
Marion	94	46	73.2		9.13							Lock Haven	95	50	74.4		5.16
Medina	92	45	71.6		8.46							Lock No. 4	89	51	72.6		12.35
Millfordton	92	43	71.6		7.77							Lycippus	89	51	72.6		12.94
Milligan	96	50	76.2		8.48							Mifflin	89	51	72.6		6.10
Millport	92	45	71.8		7.49							Oil City	89	51	72.6		6.69
Montpelier	92	45	71.8		10.62							Ottsville	89	51	72.6		9.69
Napoleon	97	47	72.4		7.71							Parker	89	51	72.6		6.99
Neapolis	89	49	71.4		11.43							Philadelphia	95	59	77.8		3.21
New Alexandria	89	49	71.4		11.28							Point Pleasant	94	55	76.6		7.12
New Berlin	93	47	71.8		7.42							Pottstown	94	55	76.6		6.30
New Bremen	94	50	73.2		7.98							Quakertown	93	49	73.0		8.30
New Comerstown	94	46	72.2		9.77							Reading	93	49	73.0		3.92
New Holland	96	50	74.8		5.71							Renovo	89	51	72.6		5.17
New Moscow	94	48	73.0		10.94							Ridgway	89	51	72.6		7.49
New Paris	94	48	73.0		5.33							Saegertown	90	41	69.1		5.48
New Waterford	98	47	74.0		8.11							St. Marys	87	45	69.7		6.06
North Lewisburg	98	47	74.0		14.15							Salem Corners	90	53	71.0		6.95
North Royalton	95	51	72.6		6.53							Scranton	93	47	72.4		4.81
Norwalk	97	40	71.2		7.26							Seisholtzville	93	47	71.8		10.86
Oberlin	94	46	72.6		7.35							Selinsgrove	93	47	71.8		6.96
Ohio State University	94	47	73.2		7.90							Shawmont	89	40	67.0		3.26
Orangeville	92	44	71.2		3.60							Shinglehouse	89	40	67.0		6.14
Ottawa	96	47	74.4		7.83							Sinamahoning	89	40	67.0		7.28
Pataaskala	94	45	72.7		11.83							Smethport	88	40	68.1		7.19
Peoli	96	45	74.0		8.68							Smiths Corners	87	45	67.7		7.21
Perry	93	48	73.2		6.15							Somerset	87	45	67.7		10.55
Philo	93	48	73.2		9.02							South Bethlehem	91	64	77.2		
Plattsburg	91	47	73.4		10.30							South Eaton	88	50	71.1		4.66
Pomeroy	100	51	75.7		9.47							State College	89	50	71.1		5.56
Portsmouth	100	52	77.1		7.33							Sunbury	89	50	71.1		3.27
Portsmouth	100	52	77.1		7.33							Towanda	92	47	71.8		4.57
Richwood	92	45	72.0		6.45							Uniontown	91	56	73.0		15.59
Ridgeville Corners	92	45	72.0		10.73							Warren	87	46	68.0		6.28
Ripley	93	53	75.0		7.79							Waterville	88	49	66.4		3.56
Rittman	92	40	68.8		8.70							Wellsboro	88	49	66.4		5.67
Rockyridge	97	48	73.2		6.90							West Chester	91	58	75.4		3.54
Rosewood	91	47	72.3		8.90							West Newton	89	51	72.6		11.46
Sharon Center	91	50	75.1		7.04							White Haven	98	58	74.3		7.60
Shenandoah	92	44	71.7		7.60							Wilkesbarre	94	50	74.2		6.30
Sidney	96	49	74.0		7.64							Williamsport	88	51	73.4		4.16
Sinking Spring	93	51	74.6		7.32							York	94	51	74.6		4.00
Springboro	95	48	74.2		6.31												
Spring Valley	95	48	74.2		6.00												
Strongsville	97	44	72.0		7.95												
Sylvania	97	44	72.0		7.14												
Thurman	98	51	77.0		6.65												
Tiffin	91	50	73.2		4.89												
Upper Sandusky	91	49	73.3		5.93												
Urbana	89	47	73.2		10.10												
Vanceburg	95	52	75.9		6.12												
Van Wert	93	47	72.6		10.18												
Vermilion	92	48	71.4		5.16												
Vickery	94	51	73.4		7.64												
Walnut	93	45	71.4		9.85												
Warren	93	45	71.4		5.19												
Warsaw	102	44	73.6		7.27												
Wauseon	93	47	72.4		11.01												
Waverly	97	50	77.2		7.12												
Waynesville	91	48	72.9		7.87												
Westerville	91	48	72.9		7.43												
Willoughby	92	45	70.2		8.06												
Wooster	92	45	70.2		8.06												
Youngstown	92	48	72.0		6.60												
Oklahoma.						Pennsylvania.						Rhode Island.					
Alva	107	60	81.7		3.45	Altoona	92	54	74.7	4.22		Bristol	84	57	70.9		2.88
Anadarko	109	57	84.1		1.36	Aqueduct	98	51	77.0	7.11		Kingston	89	53	70.0		2.11
Arpabot	105	62	80.8		4.77	Beaver Dam	98	51	77.0	8.46		Lonsdale	91	53	73.4		1.57
Beaver	105	54	80.6		2.28	Bethlehem	88	50	71.2	5.80		Pawtucket	91	53	73.4		1.55
Burnett	102	58	81.0		1.50	Blooming Grove	88	50	71.2	5.80							
Clifton	107	58	82.7		1.96	Brookville	88	50	71.2	5.80							
Fort Reno	104	62	81.6		4.05	Browers Lock	88	50	71.2	5.80							
Fort Sill	103	60	83.2		1.21	Cameron	88	50	71.2	5.80							
Guthrie	103	62	80.3		5.45	Canonsburg	90	55	73.4	11.07							
Keokuk Falls	104	54	80.4		2.06	Carlisle	95	56	75.6	4.64							
						Cassandra	90	52	73.6	6.75							
						Cedarhurst	90	50	72.2	5.06							
						Centerhall	90	50	72.2	5.06							
						Chambersburg	94	49	73.2	4.09							
						Coatesville	94	52	75.3	3.04							

TABLE II.—Meteorological record of voluntary and other cooperating observers—Continued.

Stations.	Temperature. (Fahrenheit.)			Precipitation.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
<i>South Carolina—Cont'd.</i>				<i>Ins.</i>	<i>Ins.</i>
St. Stephens†	96	58	79.0	3.43	
Santuck†	105	74	89.0	7.55	
Shaw Fork *†				7.40	
Smiths Mills†	102	65	79.9	7.96	
Society Hill†	102	54	80.4	7.45	
Spartanburg†	96	68	80.6	11.15	
Statesburg†	97	64	80.8	8.83	
Trenton†	96	68	80.6	8.86	
Trial†	95	51	77.6	8.05	
Walhalla†	96	60	79.4	9.94	
Winnabow†	103	69	83.2	5.98	
Yemassee†	97	59	79.2	8.13	
<i>South Dakota.</i>					
Alexandria†	106	49	72.6	2.72	
Armour†	102	48	72.9	2.21	
Ashcroft†	99	43	68.2	3.58	
Brookings†	99	48	69.8	2.00	
Canton *†	99	48	68.4	2.78	
Castlewood†	92	39	67.0	0.90	
Clark†	92	45	67.7	2.00	
Cross†	93	41	64.8	2.17	
Edgemont†				0.42	
Farmington†				1.25	
Faulkton†	103	46	70.2	3.43	
Flandreau†	103	44	68.6	2.54	
Forestburg†	105	46	72.6	1.93	
Forest City†	108	48	74.6	5.25	
Fort Meade†	102	50	73.6	0.72	
Gary†	95	41	69.6	0.47	
Goudyville *†	97	48	70.6	3.69	
Greenwood†	105	52	75.4	3.90	
Highmore†	99	48	69.9	6.07	
Hitchcock†				4.56	
Hotchkiss†	104	47	68.6	3.34	
Howard†	103	45	70.7	1.17	
Kimball†	103	45	72.9	5.43	
Leola†	106	46	74.6	5.37	
Vallette†	101	49	74.2	2.85	
Menno†	104	49	73.8	2.29	
Millbank†	94	45	68.6	1.04	
Mitchell†	102	45	71.2	2.37	
Nowlin†	107	46	73.0	0.14	
Oelrichs†	105	49	73.0	1.90	
Parker†	99	49	71.2	3.61	
Parkston†	101	35	65.1	1.42	
Plankinton†	105	46	72.8	3.69	
Rochford†				2.78	
Rosedale†	103	50	73.6	6.63	
St. Lawrence†	99	49	71.6	5.30	
Shiloh†	105	45	71.2	6.82	
Silver City†				3.28	
Sion Falls†	102	44	71.5	1.67	
Tyndall†	98	50	74.4	4.02	
Watertown†	92	40	65.6	0.62	
Wentworth†	98	42	69.2	1.81	
Wessington Springs†	97	51	71.3	4.69	
Yankton†	100	52	72.7	3.76	
<i>Tennessee.</i>					
Andersonville *†	95	54	78.4	9.61	
Arlington†	102	58	81.2	0.80	
Ashwood†	96	63	79.1	7.25	
Benton (near)†	98	51	78.6	6.82	
Bolivar†	102	56	79.1	4.31	
Bristol†	91	52	73.6	7.74	
Brownsville†	101	60	81.2	4.52	
Carthage†				9.24	
Clinton†				15.72	
Covington†	103	64	85.8	2.76	
Decatur†	97	51	77.7	7.67	
Dyersburg†	100	58	81.7	3.57	
Elizabethton†	96	54	76.0	10.56	
Elk Valley *†	89	58	73.5	10.08	
Fairmount *†	89	60	73.1	6.80	
Florence†	98	59	77.6	9.96	
Greenville†	90	51	73.7	11.85	
Hohenwald *†				7.82	
Jackson†	98	63	80.4	7.55	
Johnsonville†	99	52	80.2	7.78	
Jonesboro *†	98	59	73.8	9.57	
Liberty†	94	57	77.6	10.07	
Loudon†				9.85	
Lynnville†	95	57	76.7	7.18	
McKenzie *†	97	62	79.2	4.13	
McMinnville†	94	61	77.4	8.45	
Millan†	99	58	80.8	4.02	
Millon†	97	61	78.8	3.94	
Newport *†	94	57	77.6	9.69	
Nunnally†	95	60	78.6	6.58	
Palmetto†	95	56	78.9	8.79	
Pope†	98	60	79.0	1.30	
Riddletown†	94	60	77.0	9.91	
Rockwood†				11.82	
Rogersville†	90	54	73.7	7.83	
Rugby†	94	59	74.3	11.32	
St. Joseph†	102	51	79.5	2.16	
<i>Tennessee—Cont'd.</i>				<i>Ins.</i>	<i>Ins.</i>
Savannah†	98	63	81.6	3.77	
Sewanee†	87	55	73.7	6.75	
Springdale *†	96	60	77.6	14.82	
Tellus Plains†	97	51	77.8	7.43	
Trenton†	97	56	79.0	3.87	
Tullahoma†	94	52	75.8	10.40	
Union City†	97	57	79.8	6.11	
Waynesboro *†	99	62	79.0	3.60	
<i>Texas.</i>					
Albany *†	92	63	78.2	3.48	
Arthurs†				0.68	
Austin *†	101	68	84.6	4.05	
Austin *†	99	67	82.4		
Ballinger†	100	63	81.4	5.74	
Beville†	103	70	84.6	5.44	
Boerne *†	99			3.25	
Brady†	102	72	82.6	6.71	
Brazoria†	102	62	83.2	2.37	
Brenham†	97	72	82.6	7.03	
Brighton†	100	71	85.4	2.07	
Brownwood *†	98	71	85.4	1.13	
Burnet *†	105	62	84.9	2.93	
Camp Eagle Pass†	102	66	83.4	1.01	
Coleman *†	108	66	86.8	3.00	
College Station†				4.75	
Colmesneil†	98	69	83.7	0.48	
Columbia†				1.93	
Corsicana *†	95	70	81.2	6.99	
Cuero†	104	62	86.0	1.32	
Dallas†	101	71	85.5	3.36	
Danewang†	102	64	83.1	2.69	
Dean†	101	71	84.3	8.20	
Dublin†	93	58	75.5	6.57	
Duval *†	102	66	83.6	1.22	
Estelle†	105	72	86.4	1.03	
Forestburg†	102	62	84.1	2.37	
Fort Brown†	104	62	83.6	3.35	
Fort Clark†	97	65	84.4	1.63	
Fort McIntosh†	104	65	80.2	3.66	
Fort Ringgold†	100	69	85.8	4.07	
Fort Stockton†	104	70	86.8	1.00	
Fort Worth†				3.82	
Fredericksburg *†	105	65	87.0		
Gainesville†	98	67	81.7	2.56	
Georgetown *†	102	66	83.8	2.13	
Goliad†	94	72	84.7	1.97	
Graham†				0.90	
Grapevine†	106	62	86.7	0.69	
Hale Center†	102	64	84.0	2.98	
Hallettsville†	94	61	76.1	6.85	
Haskell†	104	70	84.8	3.01	
Hearne†	106	55	82.4	3.34	
Hewitt†	104	70	84.8	1.60	
Houston†	107	63	87.0	2.14	
Huntsville†				1.38	
Kerrville†	98			3.44	
Lampasas†	100	69	84.2	1.42	
Llano *†				2.50	
Longview†	102	64	81.4	2.00	
Lufkin†	109	67	83.6	1.38	
Luling†	102	72	86.6	1.53	
Mann†	104	66	86.5	3.79	
Marathon†	105	68	86.4	2.28	
Menardville *†	100	72	84.8	3.84	
Mount Blanco†	103	65	84.8	2.35	
New Braunfels†	94	60	80.4		
Orange†	100	65	83.2	2.78	
Panther†	93	56	77.5	4.10	
Paris†	99	70	83.6	1.10	
Point Isabel *†	93	68	77.6	2.20	
Rheinland†				0.25	
Roby†	104	65	84.7	0.80	
Rockport *†	92	82	85.2	0.25	
Round Rock†	105	65	84.4	2.50	
Runge†	101	59	80.7	1.48	
San Antonio†	98	78	86.3		
San Marcos *†				1.50	
San Marcos *†	104	67	84.0	2.97	
Sierra Blanca†	101	71	85.2	2.57	
Stafford†				1.35	
Temple *†	102	69	84.4	1.28	
Temple *†	95	62	75.8	4.45	
Tulla†				7.23	
Twigg†	99	69	84.4	1.59	
Tyler†	100	70	85.6	1.50	
Valentine†	98	54	76.2	4.36	
Victoria†	103	68	86.0	0.70	
Waco†	102	64	84.3	1.71	
Waxahachie†	100	60	76.5		
Weatherford†				5.77	
Wichita Falls†	102	73	87.4	0.90	
Alpine City†	100			3.80	
	102	63	84.8	1.32	
				0.32	
				2.08	
<i>Utah—Cont'd.</i>				<i>Ins.</i>	<i>Ins.</i>
Blue Creek *†	99	66	78.8	T.	
Brigham City†				1.96	
Cisco†	106	53	81.2	0.12	
Corinne *†	100	60	84.8	1.38	
Fillmore†	108	43	74.8	2.36	
Fort Duchesne†	100	45	70.4	1.45	
Giles†	106	50	79.7	0.61	
Grover†	93	42	66.2	0.80	
Heber†	94	36	65.9	3.35	
Kelton *†	90	58	76.5	0.00	
Koosharem†	90	38	64.4	3.85	
Levan†	98	46	70.6	2.26	
Loa†	95	39	67.0	2.57	
Logan†	97	51	71.2	1.40	
Mammoth†	96	49	71.1	2.84	
Manti†	106	38	71.3	1.60	
Millville†				1.52	
Moab†	98	57	79.7	0.66	
Mount Pleasant *†	100	55	71.2	2.69	
Ogden *†	97	55	76.1	0.30	
Park City†	87	42	63.2	0.71	
Parowan†	98	44	70.9	1.69	
Promontory *†	108	57	75.5	0.75	
St. George†	111	49	79.4	2.98	
Scipio†	95	35	66.9	2.82	
Snowville†	95	44	69.4	2.30	
Soldier Summit†	95	33	62.2	0.86	
Terrace *†	105	54	81.7		
Thistle†	97	47	71.6	2.43	
Tooele†	96	52	73.1	0.88	
Vernal†	95	49	71.4	1.86	
<i>Vermont.</i>					
Brattleboro†	92	49	72.0	2.77	
Burlington†	93	57	73.5	3.83	
Chelsea†	86	45	66.8	3.96	
Cornwall†	92	50	70.5	2.97	
Enosburg Falls†	89	47	69.6	4.10	
Hartland†	90	43	67.3	2.90	
Jacksonville†	91	40	65.6	5.07	
Norwich†	92	44	67.4	4.34	
St. Johnsbury†	88	47	68.9	3.79	
Stratford *†	86	51	66.6	4.56	
Vernon *†	92	60	73.1	3.76	
Wells†	89	48	70.0	3.66	
Woodstock†	93	42	70.2	3.87	
<i>Virginia.</i>					
Alleghany *†	90	58	71.9		
Ashland†	97	57	77.2	6.64	
Bigstone Gap†	92	50	71.6	9.90	
Birdsnest *†	94	66	79.9	3.35	
Blacksburg†	90	42	70.5	7.18	
Buckingham†	98	54	76.8	6.08	
Burkes Garden†	86	50	69.6	3.98	
Callville†					

TABLE II.—*Meteorological record of voluntary and other cooperating observers—Continued.*

Stations.	Temperature. (Fahrenheit.)			Precipitation.		Stations.	Temperature. (Fahrenheit.)			Precipitation.		Stations.	Temperature. (Fahrenheit.)			Precipitation.	
	Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.		Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.		Maximum.	Minimum.	Mean.	Rain and melted snow.	Total depth of snow.
Washington—Cont'd.						Wisconsin—Cont'd.						Montana.					
Ellensburg†	93	48	71.4	0.00	Ins.	Meadow Valley†	91	40	67.8	3.49	Ins.	Sun River.....	96	33	64.8	1.45	Ins.
Ellensburg (near)	103	50	75.0	0.00		Medford†	100	37	68.7	6.15		Missouri.					
Fort Simcoe†	112	45	78.2	0.00		Menasha.....	92	42	68.2	2.57		Oakridge*†	57	70.8	2.90		
Fort Spokane	107	43	73.3	0.00		Neillsville†	92	42	68.2	2.65		Nebraska.					
Grandmount†	97	44	67.6	0.00		New Holstein	91	46	69.4	7.10		Alliance.....				4.00	
Hunter†	91	37	64.2	0.01		New London	90	45	69.0	3.90		Alma.....				4.42	
Kennewick.....	106	55	78.3	0.00		Oconomowoc†	92	41	71.4	3.75		Ashland δ*1	100	55	74.2	2.47	
Lakeside†	93	52	74.9	0.01		Oconto.....	93	41	69.0	1.77		Blair.....				4.25	
Madrone*†1	96	45	63.6	0.00		Osceola†	100	39	69.5	1.83		Cook.....	95	58	75.6	4.86	
Montercisto†	88	40	64.0	T.		Pepin.....	95†	42†	69.6†	0.67		Cornlea.....				2.78	
Moxee Valley†	105	48	77.0	T.		Pine River†	91	43	69.8	3.26		Curtis δ				4.56	
New Whatcom†	85	40	65.8	0.10		Portage†	94	46	71.1	2.78		Divide.....				3.79	
Olga†	79	45	61.0	0.00		Port Washington	96	44	69.7	1.74		Grand Island α*	102	55	74.2	3.96	
Olympia†	93	42	66.5	0.00		Prairie du Chien	99	41	70.2	2.18		Grand Island δ	95	47	70.6	3.94	
Pomeroy†	104	57	80.6	0.23		Racine.....	97	49	71.2	4.94		Holdrege δ*1	99	55	71.6	4.70	
Pullmant.....	94	44	70.8	0.15		Sharon†	95	42	70.3	7.50		Imperial δ*1	96	52	76.9	4.18	
Queets†	89	42	61.8	0.21		Shawano.....	90	41	68.2	4.20		Loup α*	95	56	76.4	12.70	
Rosalia†	99	38	69.1	0.60		Spooner†	98	36	67.4	1.83		Lincoln α	94	49	71.7	3.05	
Shoalwater Bay*10	86	51	61.8			Stevens Point†	92	40	68.5	2.94		Lyons.....				5.10	
Silvercreek*1	95	44	64.4	T.		Sturgeon Bay Canal	92	45	65.4			McCool Junction				2.58	
Snohomish†	87†	43†	64.2†	0.00		Valley Junction†	92	40	67.8	5.16		Nebraska City δ*1	96	56	73.8	2.82	
Southend†	96	44	65.8	0.00		Viroqua.....	94	46	70.3	1.48		Ord.....	97	42	71.4	8.37	
Stampede†	96	42	66.2	0.00		Watertown†	94	44	72.3	4.49		Palmer δ				5.88	
Stillaquamish	84	42	62.8	T.		Waukesha†	92	47	71.2	2.59		Ravenna δ*1	92	58	73.1	2.23	
Sunnyside†	105	49	77.2	T.		Waupaca†	94	44	71.0	2.64		Red Cloud α				2.85	
Tacomat.....	88	48	66.2	0.00		Wausau.....	90	42	68.7	1.45		Republican*1	100	58	82.6	2.25	
Union City†	93	50	70.8	0.00		Westbend.....	92	42	69.6	2.14		St. Libory.....	97	48	71.1	2.98	
Vashon†	85	47	64.6	0.00		Westfield†	92	44	70.4	3		St. Paul.....	96	52	73.5	5.54	
West Ferndale†	86	48	66.2	T.		Wyoming.						Sargent.....				3.97	
West Virginia.						Bighorn Ranch†	84	36	61.0	1.45		Spencer.....				6.05	
Beckley.....	96	46	74.4	3.90		Fort Laramie†	101†	50†	74.9†	1.41		Stratton.....				2.80	
Beverly†	90	54	73.2	15.60		Fort Washakie	96	44	66.9	1.67		Stromsburg.....				2.06	
Bloomery†	91	46	70.5	6.13		Fort Yellowstone.	88	37	62.4	2.09		Tecumsehδ				3.24	
Buckhannon α†				13.63		Laramie.....	82	41	62.3	1.66		Weeping Water*	95	47	69.5	2.70	
Buckhannon δ†	89	49	71.7			Lusk†	102	44	70.7	1.08		Wisner.....				4.23	
Burlington†	92	50	73.0	7.82		Sheridan.....	98	40	68.2	1.09		Woodlawn.....				1.30	
Charleston†				4.83		Sundance.....	95	45	67.2	2.38		Nevada.					
Dayton†				14.10		Wheatland.....	90	32	70.9	0.52		Austin.....	87	36	64.0	0.11	
Elkhorn†	89	57	73.7	7.82		Mexico.						Battle Mountain*1	96	45	71.8	0.00	
Fairmont†				13.33		Ciudad P. Diaz.....	99	72	86.8	3.21		Belmont.....	105	37	69.6	1.10	
Glenville†	90	52	73.3	14.15		Leon de Aldamas	89	58	72.4	1.52		Beowawe*2	97	51	78.1	T.	
Grafton†	91	47	72.3	11.91		Mexico.....	82	52	65.2	3.94		Candelaria.....	98	41	71.4	0.31	
Green Sulphur	90	55	74.2	2.91		Puebla.....	85	52	65.3	4.24		Carlin*1	94	39	62.0	0.00	
Harpers Ferry†				5.08		Topolobampo*1	94	80	86.4	1.84		Carson City.....	88	38	63.5	0.12	
Hewett†	97	58	76.0	5.74		New Brunswick.					Cloverdale*1	90	50	72.0	0.07		
Hinton α†				4.35		St. John.....	81	49	61.8	8.12		Cranes Ranch.....				0.16	
Hinton δ†	84	56	70.0			West Indies.					Downeyville.....	99	44	74.2	0.20		
Marlinton†	87	53	71.0	7.80		Grand Turk Island.....				2.96	Elko*2	94	46	70.1	0.30		
Martinsburg†	95	53	74.5	5.64		Late reports for June, 1896.											
Monarch*†1	93	50	72.6	4.06		Alaska.											
Morgantown α†				13.98		Holy Cross Mission.....	79	31	51.3	1.98		Arizona.					
Morgantown δ†	93	49	73.6	9.80		Walnut Grove.....				0.06		California.					
New Martinsville†	93	54	74.0	15.09		Northhoff.....											
Nuttallburg†	90	52	70.9	4.30		Roseville (near)*3	104	48	72.8	0.00		Nordhoff.....	112	42	69.2	0.00	
Oldfields†	94	49	74.1	6.09		Santa Paula.....	97	47	67.8	0.00		Roseville (near)*3	104	48	72.8	0.00	
Pennsboro	93	48	74.1	13.54		Sneddens Ranch*1	94	30	59.9	0.00		Santa Paula.....	97	47	67.8	0.00	
Phillippi.....	94	54	75.2	15.70		Westpoint.....				0.00		Sneddens Ranch*1	94	30	59.9	0.00	
Point Pleasant†	95	53	76.1	8.21		Colorado.						Westpoint.....				0.00	
Powellton†	92	56	73.5	4.50		Cameron Pass.....	70	23	48.6			Colorado.					
Rowlesburg†				12.14		Holyokeδ				1.28		Cameron Pass.....	70	23	48.6		
Sandyville†	94	49	74.7	7.83		Manhattan.....				0.85		Holyokeδ				1.28	
Spencer†				7.10		Sherwood Ranch.....	86	31	57.2			Manhattan.....				0.85	
Tannery*1	87	48	67.5	15.15		Connecticut.						Sherwood Ranch.....	86	31	57.2		
Weston α†	95	58	75.9			North Grosvenor Dale..	92	39	63.2	3.01		Connecticut.					
Wheeling α†				11.08		Illinois.						North Grosvenor Dale..	92	39	63.2	3.01	
Wheeling δ†	94	52	75.0	11.84		Cordova.....				2.15		Illinois.					
White Sulphur Springs†	94	49	71.6	5.30		Lagrange.....	88	42	66.8	2.63		Cordova.....				2.15	
Wisconsin.						Rushville.....	92	51	72.4	3.72		Lagrange.....	88	42	66.8	2.63	
Amherst.....	90	41	69.6	2.33		Iowa.						Rushville.....	92	51	72.4	3.72	
Antigo†	92	34	65.9	2.63		Fayette.....	80	42	68.0	2.46		Iowa.					
Apollonia*†1	91	44	72.1	2.96		Hays.....	100	51	77.2	6.19		Fayette.....	80	42	68.0	2.46	
Bayfield†	96	42	68.6	1.71		Franklin.....	97	61	80.6	8.36		Hays.....	100	51	77.2	6.19	
Beloit.....	97	50	72.4	5.77		Petit Manan*1	68	45	56.7			Franklin.....	97	61	80.6	8.36	
Black River Falls.	98			3.94		Massachusetts.				2.33		Petit Manan*1	68	45	56.7		
Boscobel†	95	44	70.8	2.26		Cambridge δ	90	46	64.4			Massachusetts.				2.33	
Centralla.....	92	42	70.6	1.28		Egg Rock, Nahant.....	85	48	62.4			Cambridge δ	90	46	64.4		
Chilton.....	92			3.80		Hyde Park*5				50.62		Egg Rock, Nahant.....	85	48	62.4		
Citypoint.....	93	42	69.2	2.85		Lowell δ	90	41	63.9			Hyde Park*5				50.62	
Crandon†	93			3.80		Monson.....	90	35	64.2	3.10		Lowell δ	90	41	63.9		
Delavan†	96	42	72.0	8.30		Roxbury.....	89	48	64.1	2.98		Monson.....	90	35	64.2	3.10	
Depere†	91	42	69.8	1.48		Salem.....				2.50		Roxbury.....	89	48	64.1	2.98	
Easton*1	94	52	70.4	4.27		Somerset*1	93	47	68.4	5.32		Salem.....				2.50	
Eau Claire.....	94	43	70.1	2.67		Turners Falls.....	88	44	64.8	1.62		Somerset*1	93	47	68.4	5.32	
Florence†	90	36	66.0	1.91		Worcester α	88	40	63.7	1.55		Turners Falls.....	88	44	64.8	1.62	
Grand River Lock.....				2.92		Mississippi.						Worcester α	88	40	63.7	1.55	
Grantsburg†	95	43	68.4	1.30		Hazlehurst.....	98	56	79.9	10.22		Mississippi.					
Hartford.....				3.11		Mosspoint.....	94	64	80.4	5.65		Hazlehurst.....	98	56	79.9	10.22	
Harvey†	95	43	71.6	4.34		NOTE.—For explanatory notes see previous Review.											
Hayward†	91	39†	67.2†	1.40													
Hillsboro.....	93	38	68.9	2.57													
Koepenick*†1	88	48	65.8	2.70													
Lancaster†	95	46	71.6	2.99													
Lincoln†2				1.62													
Madison†	92	52	72.1	3.62													
Manitowoc†	92	44	68.0	2.91													

NOTE.—For explanatory notes see previous REVIEWS.

TABLE III.—Data from Canadian stations for the month of July, 1896.

Stations.	Pressure.			Temperature.		Precipitation.		Prevailing direction of wind.	Total depth of snow.
	Mean not reduced.	Mean reduced.	Departure from normal.	Mean.	Departure from normal.	Total.	Departure from normal.		
St. John's, N. F.	29.82	29.96	-.01	60.6	+ 0.4	5.62	.....	w.	0.0
Sydney, C. B. I.	29.90	29.96	+.05	63.4	+ 1.9	5.70	+ 1.30	sw.	0.0
Grindstone, G. St. L.	29.82	29.85	.....	61.0	.....	2.30	.....	sw.	0.0
Halifax, N. S.	29.88	29.91	+.03	63.0	+ 0.5	8.73	+ 4.48	w.	0.0
Grand Manan, N. B.	29.91	29.96	.....	62.2	.....	5.29	+ 1.45	w.	0.0
Yarmouth, N. S.	29.92	30.00	+.07	58.8	- 1.2	5.78	+ 2.71	s.	0.0
St. Andrews, N. B.	29.88	29.92	.....	63.1	.....	6.18	+ 2.15	se.	0.0
Charlottetown, P. E. I.	29.88	29.92	.....	65.1	.....	4.70	+ 0.73	sw.	0.0
Chatham, N. B.	29.88	29.90	+.02	66.2	+ 3.2	3.89	+ 0.81	w.	0.0
Father Point, Que.	29.84	29.87	+.03	58.0	+ 1.0	3.46	+ 0.24	w.	0.0
Quebec, Que.	29.60	29.92	+.05	65.8	+ 0.8	5.19	+ 1.23	w.	0.0
Montreal, Que.	29.74	29.94	+.06	68.0	+ 0.5	4.84	+ 0.27	sw.	0.0
Rockliffe, Ont.	29.44	29.94	+.05	63.1	+ 0.1	5.63	+ 2.51	nw.	0.0
Kingston, Ont.	29.66	29.97	+.07	67.4	+ 0.6	1.67	- 1.59	sw.	0.0
Toronto, Ont.	29.61	29.98	+.04	68.2	+ 0.7	2.18	- 0.79	nw.	0.0
White River, Ont.	28.65	29.97	.....	60.6	+ 0.1	1.21	- 2.10	w.	0.0
Port Stanley, Ont.	29.38	30.00	+.06	68.0	.....	4.21	+ 0.66	w.	0.0

TABLE III.—Data from Canadian stations—Continued.

Stations.	Pressure.			Temperature.		Precipitation.		Prevailing direction of wind.	Total depth of snow.
	Mean not reduced.	Mean reduced.	Departure from normal.	Mean.	Departure from normal.	Total.	Departure from normal.		
Saugeen, Ont.	29.92	29.97	+.04	65.8	+ 2.3	1.86	- 0.17	n.	0.0
Parry Sound, Ont.	29.30	29.97	+.05	65.8	+ 0.8	1.39	- 1.04	w.	0.0
Port Arthur, Ont.	29.34	29.92	+.04	62.8	+ 0.7	1.75	- 1.26	w.	0.0
Winnipeg, Man.	29.14	29.94	+.05	65.6	+ 1.6	2.01	- 1.21	n.	0.0
Minneapolis, Man.	28.19	29.94	+.10	62.8	+ 1.3	3.56	+ 1.02	nw.	0.0
Qu'Appelle, Assin.	27.74	29.93	+.07	63.0	+ 0.0	2.50	+ 0.05	nw.	0.0
Medicine Hat, Assin.	27.68	29.89	+.05	70.2	+ 2.7	1.11	- 0.61	w.	0.0
Swift Curr't, Assin.	27.45	29.93	+.08	67.3	+ 2.8	0.26	- 1.86	sw.	0.0
Calgary, Alberta.	26.48	29.91	+.01	63.2	+ 4.2	1.84	- 0.74	w.	0.0
Prince Albert, Sask.	28.36	29.82	.....	63.3	.....	3.09	.....	nw.	0.0
Edmonton, Alberta.	27.71	29.98	+ .10	63.1	+ 2.2	2.07	- 1.08	nw.	0.0
Battleford, Sask.	28.25	29.92	.....	65.6	.....	0.94	.....	nw.	0.0
Spences Br'ge, B. C.	29.14	29.93	.....	74.0	.....	0.00	.....	sw.	0.0
Hamilton, Bermuda	30.11	30.37	+ .13	79.9	.....	1.94	.....	sw.	0.0
Banff, Alberta. ....	.....	.....	.....	58.6	.....	1.13	.....	sw.	0.0
Esquimalt, B. C.	29.98	30.01	.....	58.6	.....	T.	.....	s.	0.0
Ottawa, Ont.	29.64	29.99	.....	67.2	.....	3.04	.....	w.	0.0

TABLE IV.—Meteorological observations at Honolulu, Republic of Hawaii, by Curtis J. Lyons, Meteorologist to the Government Survey.

Pressure is corrected for temperature and reduced to sea level, but the gravity correction, -0.06, is still to be applied.
 The average direction and force of the wind and the average cloudiness for the whole day are given unless they have varied more than usual, in which case the extremes are given. The scale of wind force is 0 to 10. Two directions of wind, connected by a dash, indicate change from one to the other; also same for force.
 The rainfall for twenty-four hours is given as measured at 6 a. m. on the respective dates.

July, 1896.	Pressure at sea level.			Temperature.					Relative humidity.			Wind.		Rain measured at 6 a. m.	
	9 a. m.	3 p. m.	9 p. m.	6 a. m.	3 p. m.	9 p. m.	Maximum.	Minimum.	6 a. m.	3 p. m.	9 p. m.	Direction.	Force.		Cloudiness.
1 ...	<i>Ins.</i>	<i>Ins.</i>	<i>Ins.</i>	74	82	74	83	72	76	58	72	ne.	1-3	8-1	<i>Ins.</i>
2 ...	30.16	30.10	30.15	74	83	75	84	73	75	49	62	ene.	3	4	0.06
3 ...	30.12	30.06	30.11	73	83	75	84	73	75	55	68	ene.	3	4	0.00
4 ...	30.14	30.09	30.13	76	82	73	83	73	55	56	68	ne.	3	4	T.
5 ...	30.14	30.09	30.12	74	80	76	85	71	74	61	74	ne.	0-5	1	0.00
6 ...	30.15	30.08	30.12	73	81	74	83	73	52	69	74	ne.	1	2	0.00
7 ...	30.10	30.05	30.10	70	83	75	84	69	77	62	70	ne.	1	3	0.05
8 ...	30.08	30.02	30.07	72	81	74	82	71	77	58	66	ne.	2	5	T.
9 ...	30.10	30.05	30.08	73	81	75	83	72	65	57	64	ne.	2-4	3	0.04
10 ...	30.10	30.05	30.07	73	78	75	81	72	61	56	62	ne.	3	6	T.
11 ...	30.11	30.06	30.11	73	81	78	83	72	66	51	64	ne.	3	5	0.16
12 ...	30.10	30.04	30.10	73	80	74	84	69	73	54	66	ne.	3-1	3-2	0.01
12 ...	30.06	29.99	30.04	72	79	74	84	71	73	58	66	ene.	3-0	3	0.02

TABLE IV.—Meteorological observations at Honolulu—Continued.

July, 1896.	Pressure at sea level.			Temperature.					Relative humidity.			Wind.		Cloudiness.	Rain measured at 6 m.
	9 a. m.	3 p. m.	9 p. m.	6 a. m.	3 p. m.	9 p. m.	Maximum.	Minimum.	6 a. m.	3 p. m.	9 p. m.	Direction.	Force.		
13 ...	Ins.	Ins.	Ins.	o	o	o	o	o	%	%	%	ne.	2		Ins.
14 ...	30.03	29.97	30.02	72	82	74	85	72	61	52	58	ne.	2	1	T.
15 ...	30.04	29.99	30.03	73	81	75	85	72	72	53	70	ne.	2	1	T.
16 ...	30.07	30.00	30.06	74	81	75	84	73	69	57	70	ne.	2	7-2	T.
17 ...	30.05	29.99	30.04	73	82	75	85	72	73	58	71	ne.	1	3	0.01
18 ...	30.04	29.97	30.03	74	82	74	87	71	70	52	75	nne.	1	2	T.
19 ...	30.05	30.00	30.03	74	83	74	87	72	62	49	75	ne.	2	1	0.00
20 ...	30.08	30.05	30.06	75	82	76	88	72	73	58	70	ene.	1-3	9-3	0.00
21 ...	30.12	30.08	30.10	74	83	76	88	73	68	52	61	nne.	1-3	0.02	0.04
22 ...	30.14	30.06	30.11	75	82	76	83	75	69	52	66	ne.	2	3	0.00
23 ...	30.10	30.04	30.09	75	84	77	86	73	65	49	61	ne.	3	4	0.00
24 ...	30.10	30.05	30.07	74	82	76	84	72	77	58	70	ne.	3	4	0.07
25 ...	30.11	30.05	30.10	75	83	75	85	74	66	51	68	ne.	2	2	0.02
26 ...	30.09	30.01	30.08	73	83	76	84	73	73	53	72	ne.	1-3	0.00	T.
27 ...	30.08	30.01	30.06	73	83	76	85	73	73	59	72	ne.	3-0	1-7	0.00
28 ...	30.08	30.05	30.06	76	80	77	83	71	76	68	66	ne.	3	9-3	T.
29 ...	30.11	30.05	30.08	75	82	76	85	74	66	55	61	nne.	2-5	4	T.
30 ...	30.10	30.03	30.08	74	82	75	84	71	68	52	70	ne.	4	3	0.03
31 ...	30.05	29.98	30.05	74	82	73	85	73	65	52	70	ne.	4-0	1	0.05
81 ...	30.03	29.98	30.03	72	83	73	86	69	75	49	70	ne.	2-0	1	0.00
	30.09	30.03	30.08	73.6	81.8	75.0	84.3	72.0	70.3	65.3	68.0		2.2	3.2	0.56

Mean temperature: 6+2+9+3 is 76.5; the normal is 78.3; extreme temperatures, 57° and 89°.

TABLE V.—Mean temperature for each hour of seventy-fifth meridian time, July, 1896.

Stations.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.	Midnight.	Mean.
Bismarck, N. Dak.	63.2	61.9	60.4	59.4	58.3	57.8	57.8	60.2	63.4	67.3	70.5	73.4	75.7	77.3	78.1	79.4	79.7	79.7	78.9	77.2	73.5	69.6	66.8	64.5	68.9
Boston, Mass.	68.0	67.7	67.5	67.1	66.8	67.2	68.5	70.1	71.9	73.2	74.1	74.5	75.4	76.4	76.0	75.9	75.2	74.3	73.0	71.4	70.7	69.9	69.3	68.5	71.4
Buffalo, N. Y.	67.8	67.3	66.5	66.1	65.5	66.1	67.3	68.7	69.9	71.1	71.7	72.9	73.6	74.3	74.7	75.0	75.0	74.3	73.8	72.5	71.9	71.0	69.2	68.3	70.6
Chicago, Ill.	70.0	69.4	69.0	68.3	68.0	67.8	68.1	69.2	69.9	71.3	73.4	73.8	73.2	73.8	74.7	75.5	75.2	74.9	74.7	74.2	73.5	71.8	70.3	70.3	71.6
Cincinnati, Ohio.	72.6	72.0	71.6	71.2	70.6	70.4	70.6	71.8	74.5	76.5	78.5	80.3	81.2	81.9	81.9	82.0	81.8	80.3	79.0	77.3	75.9	74.6	73.6	73.6	76.3
Cleveland, Ohio.	68.2	67.6	67.4	67.1	67.0	67.0	67.6	70.0	71.9	73.5	74.6	75.2	75.7	75.7	75.8	75.7	75.0	75.3	74.7	73.5	73.3	71.8	70.0	68.9	71.8
Detroit, Mich.	67.4	66.9	66.2	65.7	65.2	64.9	65.9	68.0	70.0	72.3	74.3	75.5	76.5	77.6	77.6	77.5	77.3	76.5	75.4	73.6	71.3	69.9	69.1	68.4	71.4
Dodge City, Kans.	72.6	71.5	70.6	69.8	68.7	68.0	67.6	68.4	71.7	75.1	78.1	80.5	82.8	84.4	86.4	86.9	86.6	85.8	84.2	81.9	79.1	76.2	74.5	73.1	76.8
Eastport, Me.	55.8	55.6	55.4	55.4	55.7	57.0	58.3	59.6	61.7	63.6	65.1	66.1	67.1	67.6	67.0	66.7	65.3	63.4	61.1	59.6	58.5	57.5	56.8	56.8	60.8
Galveston, Tex.	82.6	82.5	82.4	82.0	81.1	81.4	81.3	81.8	82.5	83.4	84.1	84.9	85.3	85.7	85.7	85.6	85.1	85.0	84.4	83.9	83.4	83.0	82.9	82.7	83.4
Havre, Mont.	65.3	63.5	61.9	60.5	59.0	57.5	56.4	57.9	61.5	65.5	69.9	73.0	76.1	78.0	79.7	80.4	80.8	81.4	81.6	80.9	78.7	74.9	70.2	67.6	70.1
Kansas City, Mo.	74.2	73.2	72.4	71.5	71.1	70.4	70.6	71.7	74.2	76.5	78.7	80.3	81.6	83.0	84.2	84.9	84.7	84.5	84.0	83.2	81.6	79.6	76.6	75.3	77.6
Key West, Fla.	80.4	80.2	80.5	80.2	80.0	79.7	80.7	82.7	83.6	84.1	84.7	85.1	85.1	84.9	84.7	84.5	84.0	83.6	82.6	81.6	80.8	80.7	80.7	80.7	82.3
Memphis, Tenn.	77.9	77.2	76.6	75.9	75.2	74.5	74.9	76.4	79.0	81.2	83.5	85.6	87.2	88.5	89.5	90.0	89.5	89.4	87.9	86.5	85.1	82.1	80.4	79.2	82.2
New Orleans, La.	78.5	78.2	78.0	77.6	77.3	77.2	77.2	78.8	80.9	82.7	83.5	84.3	84.8	85.3	86.0	86.0	85.9	85.3	84.5	83.4	81.6	79.6	78.2	78.2	81.5
New York, N. Y.	69.9	69.5	69.0	68.6	68.3	68.4	69.0	70.1	71.7	73.2	74.9	76.7	78.6	77.0	77.3	76.4	76.3	75.3	74.2	74.1	72.8	72.1	71.4	70.5	72.6
Philadelphia, Pa.	72.8	72.6	72.2	72.0	71.7	71.9	73.1	74.5	76.6	78.3	79.8	81.0	82.1	82.7	82.8	83.0	82.6	81.7	80.8	79.4	77.1	75.7	74.7	73.6	77.1
Pittsburg, Pa.	70.1	69.4	68.7	68.1	67.7	67.6	68.5	70.0	72.2	74.4	76.1	77.5	79.5	80.2	79.7	80.0	79.5	78.9	77.2	75.6	74.0	72.6	71.9	71.0	73.5
Portland, Oreg.	68.8	67.4	65.3	63.8	62.2	60.8	59.4	59.0	60.5	62.3	64.0	65.6	68.4	70.7	73.6	75.8	78.4	79.8	80.2	80.3	79.3	77.3	74.0	71.7	69.5
St. Louis, Mo.	76.5	75.6	74.7	74.0	73.3	72.9	73.2	74.3	76.2	78.3	80.0	82.0	83.2	84.1	85.0	85.1	84.8	84.3	83.0	81.5	80.2	79.4	78.2	77.4	79.0
St. Paul, Minn.	67.5	66.0	64.7	63.9	62.9	61.9	61.8	63.3	66.3	69.0	72.0	73.5	75.2	76.8	78.3	78.9	78.7	79.1	78.3	77.0	74.5	72.3	70.5	68.7	70.9
Salt Lake City, Utah.	71.8	70.1	68.9	68.3	67.5	66.7	65.8	65.4	67.2	70.8	73.8	77.0	79.0	80.4	81.6	82.0	83.1	83.8	83.8	82.6	80.6	77.4	75.2	73.2	74.8
San Diego, Cal.	66.2	65.9	65.7	65.5	65.5	65.6	65.4	65.3	65.5	66.4	67.6	69.0	69.9	70.4	71.0	71.3	71.5	71.4	70.8	70.3	69.7	68.6	67.4	66.8	68.0
San Francisco, Cal.	53.7	55.6	55.5	55.2	54.8	54.8	54.7	54.6	54.9	55.8	57.6	59.4	61.3	62.4	62.9	63.3	63.1	62.6	61.5	60.3	59.0	57.8	56.5	56.2	58.1
Savannah, Ga.	77.5	77.3	77.0	76.5	76.4	76.4	77.5	80.1	82.3	84.6	86.0	87.5	88.7	88.5	87.4	86.6	85.5	83.5	82.4	80.8	80.2	79.1	78.6	78.0	81.6
Washington, D. C.	72.0	71.4	70.7	70.1	69.6	69.9	71.9	74.0	76.6	78.4	79.7	80.9	82.4	82.8	83.2	83.0	81.9	80.5	78.3	76.8	75.2	74.1	72.9	72.5	76.2

TABLE VI.—Mean pressure for each hour of seventy-fifth meridian time, July, 1896.

Stations.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.	Midnight.	Mean.
Bismarck, N. Dak.	28.263	.269	.267	.266	.267	.270	.277	.285	.291	.292	.290	.284	.275	.270	.262	.254	.242	.236	.230	.229	.226	.248	.257	.265	.264
Boston, Mass.	29.856	.855	.852	.854	.864	.871	.880	.882	.882	.881	.879	.871	.866	.862	.855	.848	.844	.847	.854	.860	.865	.866	.863	.861	.863
Buffalo, N. Y.	29.196	.192	.192	.194	.200	.206	.215	.216	.215	.214	.211	.206	.195	.185	.176	.170	.165	.164	.174	.176	.186	.187	.190	.196	.193
Chicago, Ill.	29.147	.141	.140	.140	.145	.154	.161	.170	.180	.179	.179	.180	.171	.167	.158	.145	.135	.129	.127	.130	.134	.138	.140	.142	.151
Cincinnati, Ohio	29.393	.386	.384	.384	.391	.400	.412	.417	.414	.415	.412	.409	.399	.391	.377	.369	.357	.356	.364	.368	.380	.389	.387	.389	.389
Cleveland, Ohio	29.242	.238	.233	.236	.245	.253	.262	.269	.261	.257	.254	.249	.242	.231	.222	.210	.206	.209	.215	.221	.229	.235	.239	.239	.237
Detroit, Mich.	29.237	.235	.235	.234	.237	.242	.247	.253	.257	.256	.253	.247	.241	.232	.224	.215	.212	.214	.214	.226	.235	.235	.236	.236	.236
Dodge City, Kans.	27.446	.450	.449	.447	.445	.451	.458	.464	.474	.475	.470	.466	.455	.444	.436	.409	.393	.385	.384	.392	.402	.416	.431	.439	.436
Eastport, Me.	29.860	.857	.858	.862	.868	.875	.883	.883	.883	.879	.876	.871	.863	.850	.834	.851	.851	.856	.862	.869	.873	.872	.869	.864	.867
Galveston, Tex.	30.057	.053	.048	.045	.047	.054	.066	.075	.081	.083	.083	.082	.077	.066	.054	.042	.029	.020	.018	.022	.031	.043	.062	.086	.064
Havre, Mont.	27.386	.387	.387	.387	.391	.397	.406	.415	.421	.426	.422	.419	.411	.401	.394	.383	.373	.362	.356	.356	.359	.364	.376	.381	.390
Kansas City, Mo.	29.043	.040	.035	.032	.034	.042	.054	.068	.070	.071	.070	.070	.060	.049	.036	.025	.012	.003	.002	.002	.008	.015	.026	.032	.037
Key West, Fla.	30.102	.093	.092	.078	.080	.087	.100	.113	.119	.123	.134	.119	.110	.099	.084	.072	.068	.073	.085	.097	.104	.109	.111	.107	.097
Memphis, Tenn.	29.642	.644	.642	.642	.649	.658	.670	.684	.691	.692	.695	.689	.680	.659	.640	.622	.613	.604	.603	.609	.619	.630	.636	.636	.648
New Orleans, La.	30.048	.041	.038	.040	.047	.061	.070	.082	.086	.092	.088	.082	.074	.062	.044	.029	.019	.015	.019	.017	.032	.042	.048	.049	.051
New York, N. Y.	29.693	.686	.683	.685	.692	.701	.711	.717	.716	.715	.714	.710	.704	.695	.686	.680	.677	.679	.684	.686	.696	.699	.700	.696	.696
Philadelphia, Pa.	29.917	.911	.907	.910	.915	.921	.932	.942	.944	.943	.939	.931	.918	.910	.900	.893	.889	.891	.897	.903	.912	.915	.915	.916	.915
Pittsburg, Pa.	29.173	.173	.169	.172	.176	.182	.193	.203	.201	.196	.193	.186	.175	.166	.157	.150	.141	.140	.146	.153	.160	.164	.168	.169	.171
Portland, Oreg.	29.822	.828	.835	.840	.846	.849	.856	.865	.870	.875	.875	.873	.868	.861	.845	.835	.816	.804	.789	.784	.780	.782	.791	.805	.833
St. Louis, Mo.	29.447	.446	.444	.445	.451	.458	.470	.482	.486	.488	.487	.483	.475	.462	.450	.436	.428	.419	.421	.426	.437	.434	.439	.441	.452
St. Paul, Minn.	29.123	.122	.120	.120	.123	.130	.139	.146	.150	.146	.142	.140	.132	.122	.115	.106	.097	.088	.083	.080	.086	.096	.102	.107	.117
Salt Lake City, Utah	25.665	.670	.673	.674	.671	.673	.683	.693	.705	.711	.713	.714	.712	.704	.692	.680	.668	.656	.646	.645	.645	.648	.660	.665	.678
San Diego, Cal.	29.899	.900	.900	.896	.893	.889	.887	.889	.899	.907	.914	.917	.919	.916	.910	.903	.895	.885	.874	.865	.866	.871	.879	.890	.894
San Francisco Cal.	29.806	.806	.804	.800	.796	.794	.797	.804	.815	.825	.832	.834	.836	.836	.830	.823	.809	.797	.784	.775	.775	.784	.791	.800	.806
Savannah, Ga.	30.035	.030	.028	.027	.035	.044	.057	.065	.070	.073	.070	.057	.043	.036	.029	.020	.009	.000	.008	.015	.024	.032	.036	.035	.034
Washington, D. C.	29.988	.994	.990	.991	.990	.990	.990	.970	.972	.975	.973	.966	.964	.945	.932	.921	.912	.914	.917	.920	.927	.929	.927	.929	.941

MONTHLY WEATHER REVIEW.

JULY, 1896

TABLE VII.—Average wind movement for each hour of seventy-fifth meridian time, July, 1896.

Stations.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.	Midnight.	Mean.
Abilene, Tex.	7.4	8.0	7.8	8.0	8.3	7.8	6.8	7.9	9.7	11.4	11.7	11.4	11.1	11.1	11.2	11.9	12.2	12.4	11.8	11.4	9.4	6.3	6.1	7.1	9.5
Albany, N. Y.	5.0	4.7	4.8	4.5	4.4	5.0	6.5	7.4	8.0	8.7	9.8	10.2	11.1	10.7	11.0	10.5	10.9	9.7	8.3	6.7	6.3	5.7	5.9	5.5	7.5
Alpena, Mich.	4.6	4.9	5.1	5.1	5.2	5.0	5.5	6.7	7.6	8.2	9.5	10.0	11.0	11.2	11.9	11.0	10.7	10.6	8.3	7.0	5.8	5.2	4.8	4.9	7.5
Amarillo, Tex.	14.5	14.5	14.4	14.2	14.6	14.2	13.7	13.5	14.5	16.8	16.5	16.4	16.3	16.5	16.8	16.5	17.4	19.4	18.9	19.1	17.2	15.4	14.7	14.7	15.9
Atlanta, Ga.	7.1	7.2	7.2	7.2	7.7	7.5	7.9	7.3	7.8	8.3	8.2	8.7	9.1	9.1	8.5	8.8	9.4	8.5	7.5	7.0	7.3	7.1	6.8	6.8	7.8
Augusta, Ga.	2.5	2.8	3.1	2.9	2.5	2.5	3.3	4.2	5.2	5.7	6.3	7.2	7.8	7.6	7.5	7.5	6.6	7.1	6.4	5.7	4.1	3.6	3.8	2.9	5.0
Baker City, Oreg.	2.7	3.6	4.1	5.5	6.4	6.4	7.1	7.4	7.0	5.8	4.2	2.5	3.4	3.8	4.6	4.8	5.6	5.8	6.3	6.1	5.5	4.8	4.1	3.0	5.0
Baltimore, Md.	5.9	5.3	5.5	5.3	5.4	5.2	5.1	6.0	7.0	8.1	8.9	9.0	9.8	9.5	10.0	9.5	10.2	9.6	8.5	7.1	6.7	6.1	5.7	5.5	7.3
Bismarck, N. Dak.	5.4	5.1	5.7	5.0	4.9	4.0	4.5	5.1	6.5	7.5	8.5	8.4	9.5	9.9	10.0	10.1	10.2	10.1	10.2	8.9	8.5	7.0	6.2	5.6	7.4
Block Island, R. I.	10.3	12.5	12.3	11.7	11.3	11.2	11.8	12.6	13.2	13.3	14.0	14.6	15.0	15.2	15.3	15.6	14.7	14.3	14.7	14.8	13.7	13.5	14.2	14.8	13.6
Boston, Mass.	9.2	8.7	8.6	8.5	7.8	7.6	8.4	8.8	9.4	10.1	10.4	11.8	12.3	13.3	13.4	13.5	12.4	11.3	10.4	9.7	9.5	9.1	8.7	9.5	10.1
Buffalo, N. Y.	10.6	11.0	10.9	11.1	10.8	11.1	10.3	10.8	12.3	13.6	14.0	15.3	16.0	15.3	15.8	15.1	14.9	13.9	13.1	11.2	10.5	10.4	10.9	11.4	11.1
Cairo, Ill.	5.2	5.2	5.2	5.3	5.3	5.4	5.3	5.8	6.5	6.8	7.0	7.8	8.2	8.5	8.5	8.6	8.3	8.3	7.6	5.8	5.1	5.6	5.2	5.6	6.5
Cape Henry, Va.	10.1	9.9	10.4	10.6	10.8	10.7	11.3	11.8	11.7	12.3	12.8	12.6	13.2	13.1	11.8	11.8	10.8	10.5	10.0	10.0	10.0	10.6	11.3	10.8	11.2
Charleston, S. C.	6.7	6.1	5.5	5.4	5.7	5.5	5.6	6.9	7.4	7.4	7.7	8.5	10.0	10.4	10.5	10.7	10.6	10.1	9.3	7.9	7.6	7.2	7.0	7.0	7.8
Charlotte, N. C.	4.9	4.9	4.8	4.3	4.2	4.4	4.9	5.6	6.4	7.0	7.7	7.7	7.8	7.6	7.6	7.1	7.7	7.2	6.3	5.6	5.0	5.2	5.0	4.7	6.0
Chattanooga, Tenn.	4.1	3.8	3.4	3.9	3.6	3.9	4.5	5.5	6.2	6.2	7.7	7.5	8.4	8.2	7.8	8.3	8.1	8.1	6.7	5.2	4.7	3.7	4.1	3.4	5.7
Cheyenne, Wyo.	5.9	7.0	6.7	6.8	6.1	6.4	6.5	6.2	6.3	7.2	8.5	9.4	10.0	10.7	10.7	10.9	11.4	10.3	10.1	10.3	9.2	8.2	7.3	6.6	8.3
Chicago, Ill.	15.2	14.5	14.5	14.3	13.5	12.9	12.9	12.7	13.4	14.1	14.1	14.3	15.8	16.8	16.7	17.2	17.6	17.2	16.4	15.4	14.8	13.7	14.2	14.8	14.9
Cincinnati, Ohio.	5.8	5.4	5.0	5.0	5.3	5.0	5.4	6.5	7.9	8.5	10.0	9.9	10.3	10.3	10.4	10.2	9.7	9.2	8.1	7.4	6.4	6.1	5.7	5.8	7.5
Cleveland, Ohio.	11.1	11.3	11.7	10.8	10.5	10.5	10.3	10.7	12.8	12.2	12.3	13.1	13.8	13.8	13.3	12.5	11.9	11.5	10.6	9.0	9.0	10.0	11.8	11.3	11.5
Columbia, Mo.	5.0	4.6	4.7	5.1	5.6	5.6	5.7	5.9	6.1	7.2	7.8	8.2	8.6	8.5	8.4	8.7	8.2	7.6	6.7	5.6	5.2	5.5	5.5	5.5	6.5
Columbus, Ohio.	5.4	5.4	5.5	4.6	4.6	4.7	4.4	5.2	5.9	6.6	7.1	7.6	7.6	8.1	8.8	8.6	8.3	7.3	6.0	5.9	5.5	5.4	5.1	5.5	6.2
Concordia, Kans.	5.4	5.6	5.8	5.3	4.8	4.7	4.8	5.5	6.5	7.2	7.2	7.4	7.6	7.5	7.5	7.4	7.1	7.1	6.9	5.6	4.7	4.5	5.0	5.1	6.1
Corpus Christi, Tex.	13.8	12.0	9.7	8.1	7.0	5.9	5.4	5.0	6.2	8.2	8.9	11.7	13.8	15.6	17.0	17.8	18.0	18.4	18.0	18.1	17.3	16.7	16.2	15.4	12.7
Davenport, Iowa.	5.5	5.7	5.8	5.1	5.8	5.4	5.9	7.1	7.0	7.4	8.2	8.9	9.1	9.3	9.3	9.5	9.8	9.6	9.5	7.9	6.5	5.6	5.3	5.3	7.2
Denver, Colo.	6.1	6.5	7.0	6.4	5.5	4.9	4.7	4.5	4.9	5.1	5.5	6.0	6.9	7.6	8.4	9.2	9.8	9.6	9.2	10.3	10.8	10.1	7.7	6.2	7.2
Des Moines, Iowa.	4.9	4.6	4.7	4.1	4.3	4.2	4.6	5.0	5.8	6.9	7.6	8.1	8.5	8.6	8.8	9.2	9.5	9.4	8.9	7.6	6.5	5.8	5.3	4.9	6.5
Detroit, Mich.	7.4	7.7	8.5	8.4	8.0	7.6	7.0	7.4	8.2	8.3	9.3	9.8	10.0	10.2	10.6	10.1	9.6	8.5	7.8	7.2	6.8	6.1	5.3	4.9	6.5
Dodge City, Kans.	8.9	9.9	9.5	8.7	8.1	8.1	7.5	7.9	9.9	12.0	12.9	12.6	12.7	12.9	13.7	14.7	15.3	14.5	13.9	12.2	10.4	10.1	8.7	11.1	11.1
Dubuque, Iowa.	2.5	2.5	2.5	2.5	2.7	2.4	2.4	3.3	3.6	4.4	4.8	5.5	5.9	6.2	5.9	6.5	6.3	6.5	5.8	5.4	4.0	2.9	2.6	2.5	4.2
Duluth, Minn.	7.9	7.5	6.6	6.9	6.6	6.5	6.3	6.4	6.7	7.4	7.9	8.3	8.0	8.8	9.0	8.8	9.5	9.4	8.4	7.1	6.8	7.1	7.4	7.9	7.8
Eastport, Me.	6.1	6.3	6.1	6.2	5.9	5.7	6.3	7.0	7.3	7.6	7.6	8.5	8.6	9.4	9.9	9.5	9.4	8.5	8.3	7.4	6.8	6.1	6.6	6.7	7.5
El Paso, Tex.	8.0	7.9	7.7	9.0	8.4	7.8	7.0	7.6	8.3	9.1	8.4	7.6	7.3	7.9	8.8	9.5	10.0	11.0	10.4	9.6	8.6	7.9	8.6	8.7	9.5
Erie, Pa.	8.8	9.2	9.1	9.4	9.3	9.0	9.6	9.7	10.1	10.1	10.9	11.1	11.2	11.3	11.5	10.3	9.5	8.2	7.8	7.5	7.9	8.6	8.8	8.7	9.5
Eureka, Cal.	4.2	4.2	4.0	3.8	3.8	3.6	3.1	3.1	3.2	3.8	3.8	4.5	5.3	6.9	7.5	8.8	9.0	9.0	8.5	7.9	7.0	6.1	5.5	4.3	5.4
Fort Canby, Wash.	6.3	5.9	4.9	4.8	4.5	4.4	4.1	4.0	4.1	4.1	4.5	5.1	6.2	7.4	8.5	9.2	9.4	9.2	10.3	10.8	10.7	9.8	8.9	7.8	6.9
Fort Smith, Ark.	3.9	3.7	3.2	3.4	3.7	3.8	3.9	4.1	4.6	5.8	6.9	7.4	8.1	8.6	7.6	7.5	7.7	7.6	6.8	5.8	5.5	5.3	5.1	4.1	5.6
Fresno, Cal.	10.6	10.7	9.8	9.1	8.2	6.9	5.8	5.5	4.6	4.2	4.5	4.7	4.9	4.8	5.4	5.6	6.0	6.4	6.4	7.0	8.2	9.5	9.2	9.8	7.0
Galveston, Tex.	9.4	9.2	8.9	8.9	8.2	7.4	6.9	6.6	7.7	7.6	8.7	8.5	9.7	10.2	10.7	11.5	11.9	11.5	11.2	10.7	9.4	8.9	9.4	9.4	9.3
Grand Haven, Mich.	6.7	6.2	6.1	5.9	5.5	5.2	5.7	6.0	6.9	7.5	8.8	10.2	10.6	11.0	11.5	11.1	10.3	9.2	8.2	7.0	6.3	6.1	6.3	6.2	7.7
Greenbay, Wis.	5.1	4.9	5.0	4.8	4.9	4.7	4.5	5.1	6.2	6.5	7.8	8.1	8.3	8.6	8.5	9.0	8.9	8.3	7.6	6.8	5.5	5.2	5.3	5.4	6.4
Hannibal, Mo.	5.7	5.9	6.5	7.4	6.8	6.5	6.7	6.8	8.0	8.8	9.5	9.7	9.6	9.8	9.9	9.5	9.5	8.1	6.8	6.3	5.8	5.8	6.1	6.0	7.7
Harrisburg, Pa.	4.3	4.5	4.6	4.3	4.2	4.2	4.4	5.1	5.9	6.3	7.2	7.5	8.0	8.6	8.6	8.6	8.1	7.8	6.0	4.8	5.2	5.2	4.6	4.2	5.9
Hatteras, N. C.	11.5	10.4	10.8	11.2	11.2	10.7	10.8	11.8	12.6	13.4	14.0	14.4	15.1	14.9	15.4	14.6	14.2	13.2	12.9	12.2	12.4	11.9	11.1	10.9	12.6
Havre, Mont.	4.9	4.2	4.7	4.7	4.8	4.2	4.0	4.2	5.5	7.5	7.9	8.4	8.5	8.7	9.0	8.8	8.9	8.6	8.3	6.7	5.5	4.9	4.0	4.0	6.3
Helena, Mont.	5.3	5.2	7.4	6.9	6.5	6.5	5.8	5.7	4.0	4.2	5.5	7.5	7.9	8.4	8.5	8.7	9.0	8.8	8.9	8.6	8.3	6.7	5.5	4.8	6.3
Huron, S. Dak.	9.7	9.4	9.2	9.1	8.5	8.8	8.7	8.5	9.9	10.5	10.6	11.9	12.4	12.5	12.5	12.5	13.0	12.6	12.0	12.5	10.3	10.5	10.7	9.9	10.7
Idaho Falls, Idaho.	8.2	7.1	6.6	6.2	5.9	5.4	5.2	5.3	5.5	4.8	5.0	5.7	6.6	7.1	7.2	7.8	8.4	8.4	8.4	9.4	10.7	9.3	10.0	9.2	9.9
Indianapolis, Ind.	4.3	4.1	3.9	3.9	3.9	4.1	4.7	5.3	6.2	6.8	6.6	6.6	6.6	7.1	7.4	7.8	7.8	7.6	6.8	6.1	5.6	5.1	4.7	5.2	6.2
Jacksonville, Fla.	5.9	6.5	6.3	6.3	6.3	5.6	5.8	7.3	7.2	7.9	8.1	8.4	8.9	9.1	10.6	11.7	11.1	10.4	10.1	8.4	6.5	6.2	6.2	5.8	7.8
Jupiter, Fla.	8.1	8.5	8.3	8.0	7.4	7.1	7.5	8.2	9.3	9.5	10.3	10.7	10.7	11.0	11.9	12.4	11.5	10.3	9.5	8.7	8.4	8.3	8.2	8.4	9.3
Kansas City, Mo.	6.1	6.0	6.3	5.5	5.6	6.2	5.8	6.0	6.8	7.3	7.9	8.5	8.9	8.6	8.4	8.7	8.7	8.2	7.4	6.2	6.0	6.3	5.9	7.1	7.1
Keokuk, Iowa.	5.5	5.4	4.8	5.2	4.8	5.4	5.3	5.7	5.8	6.1	7.4	8.0	7.6	8.0	8.0	7.6	7.8	7.6	6.8	6.1	5.6	5.1	4.7	5.2	6.2
Key West, Fla.	9.4	8.9	8.6	7.9	8.4	8.6																			

TABLE VII.—Average wind movement, etc.—Continued.

Stations.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.	Midnight.	Mean.
Pensacola, Fla.....	8.1	7.3	7.3	7.1	7.1	6.9	7.7	8.4	10.1	10.5	9.6	10.3	11.1	13.6	14.9	14.4	12.9	12.0	11.1	9.3	8.7	8.5	7.9	7.6	9.7
Philadelphia, Pa.....	9.0	8.5	7.7	7.8	7.6	7.4	7.9	9.0	10.0	10.8	11.5	11.6	11.6	12.0	12.1	12.0	12.4	11.8	11.0	9.7	9.2	9.5	9.6	9.4	10.0
Phoenix, Ariz.....	4.7	4.0	3.8	3.8	3.8	3.6	3.3	4.1	4.1	4.4	5.0	5.3	4.8	5.3	4.8	5.1	5.5	5.5	5.3	6.3	6.5	5.3	5.0	5.1	4.8
Pierre, S. Dak.....	7.7	7.4	6.4	6.5	7.6	7.3	6.5	7.1	7.7	9.1	10.4	10.6	11.0	10.9	10.3	11.0	11.3	10.7	10.5	10.9	9.5	9.3	9.5	9.2	9.1
Pittsburg, Pa.....	4.5	4.2	4.5	4.4	4.0	3.8	4.4	4.9	5.8	6.7	7.3	7.1	6.7	7.5	7.7	7.5	7.6	6.5	6.2	5.7	5.2	4.6	4.8	4.6	5.7
Port Angeles, Wash..	4.5	4.7	4.9	5.0	4.9	4.7	5.0	5.3	4.3	4.2	5.3	6.9	7.7	8.1	9.2	9.0	9.6	10.8	11.6	11.9	10.9	9.1	7.1	5.4	7.1
Port Huron, Mich.....	8.2	8.8	9.0	9.2	9.5	8.6	8.3	8.5	8.5	9.3	10.6	10.9	11.4	11.9	11.9	11.9	11.7	11.3	9.1	8.7	8.4	8.5	8.4	7.8	9.6
Portland, Me.....	4.6	4.9	4.9	4.7	5.0	5.0	5.2	5.8	6.6	7.2	7.8	7.8	8.3	8.5	8.6	9.2	8.9	8.2	7.1	6.7	6.5	5.6	4.9	4.7	6.5
Portland, Oreg.....	9.8	8.3	6.1	4.0	3.7	3.1	3.2	3.6	3.3	3.6	4.7	6.0	6.9	6.8	6.8	6.7	7.0	7.3	7.9	8.7	8.7	9.0	10.3	10.9	6.5
Pueblo, Colo.....	5.6	4.6	4.8	4.8	3.8	3.9	3.4	3.6	3.4	4.0	5.0	6.3	6.8	8.5	9.4	10.4	11.3	11.6	11.9	11.2	9.2	8.7	8.9	6.7	7.0
Raleigh, N. C.....	4.4	4.4	4.4	4.5	4.5	4.5	4.5	5.5	5.9	6.5	6.6	6.8	7.1	7.5	7.1	7.2	5.9	5.6	4.3	4.4	4.4	4.4	4.2	4.5	5.4
Rapid City, S. Dak.....	6.4	7.0	6.9	6.5	5.9	6.0	6.3	7.6	7.7	8.1	9.5	10.0	11.2	11.2	11.6	11.3	11.4	10.5	9.9	9.2	8.2	7.1	6.4	6.6	8.4
Red bluff, Cal.....	5.0	5.1	4.8	4.1	3.8	3.7	3.6	3.7	3.6	4.0	5.0	5.2	5.1	5.1	5.7	6.0	6.5	6.7	6.7	6.3	5.7	5.8	6.0	5.1	6.1
Rochester, N. Y.....	5.5	5.6	5.7	5.7	5.7	5.5	6.5	7.2	7.8	8.0	8.4	8.9	9.5	9.0	8.9	8.5	8.6	8.0	7.0	5.6	5.5	5.5	5.2	5.2	7.0
Roseburg, Oreg.....	2.5	1.9	1.4	1.5	1.4	1.6	1.6	1.3	1.4	1.8	2.4	3.0	3.1	3.6	4.2	5.4	6.4	7.0	7.8	8.9	9.3	8.3	6.0	3.3	4.0
Sacramento, Cal.....	10.0	9.4	9.7	9.6	9.5	9.0	8.8	8.7	8.2	6.8	7.4	6.9	7.3	7.5	7.9	7.8	8.6	9.1	9.2	9.8	10.5	10.6	11.0	10.7	8.9
St. Louis, Mo.....	8.2	8.1	8.1	7.8	7.1	7.5	7.7	8.4	9.6	10.1	10.9	11.2	11.0	10.5	10.9	10.9	10.4	10.5	9.9	9.3	8.0	8.0	8.0	8.3	9.2
St. Paul, Minn.....	4.2	4.2	4.5	4.8	4.7	4.4	4.4	4.6	5.5	6.3	6.9	7.9	7.5	8.3	8.6	8.5	8.2	8.1	7.6	7.1	6.2	5.3	4.8	4.5	6.1
Salt Lake City, Utah.....	4.4	5.4	4.2	4.1	4.2	4.0	3.7	4.6	4.0	3.8	4.0	4.8	6.2	7.2	7.8	8.1	7.7	7.5	7.2	6.9	6.3	6.3	5.2	4.9	5.5
Santa Fe, N. Mex.....	8.5	7.2	5.8	4.8	4.3	4.1	3.7	3.8	5.5	7.6	7.8	7.8	8.5	8.6	9.0	9.8	10.4	10.1	10.5	11.5	11.6	11.7	11.8	9.8	8.1
San Diego, Cal.....	3.1	2.4	2.1	2.0	2.3	2.4	2.5	2.1	2.4	2.6	3.3	5.0	6.8	8.5	9.6	9.9	10.0	9.4	9.0	8.0	6.9	5.7	4.7	3.6	5.2
Sandusky, Ohio.....	8.3	7.9	7.4	7.6	7.8	7.0	7.4	7.3	7.4	7.9	7.9	8.4	8.5	8.0	8.4	8.9	8.7	8.6	7.6	6.6	6.7	7.2	7.9	7.8	7.8
San Francisco, Cal.....	13.9	12.4	11.1	10.3	9.8	9.0	8.6	8.4	8.1	8.5	9.0	8.9	10.2	12.3	14.9	18.3	20.9	22.3	22.3	23.5	23.3	20.1	18.0	15.2	14.1
San Luis Obispo, Cal.....	2.6	2.5	2.4	2.5	2.4	2.6	2.3	2.7	2.3	2.6	3.1	3.7	4.2	5.8	6.2	7.1	7.5	7.2	7.0	7.0	6.6	5.4	4.0	3.3	4.3
Santa Fe, N. Mex.....	5.2	4.9	4.3	3.7	2.9	2.9	2.8	2.9	2.7	3.5	4.7	5.0	6.0	6.4	7.7	8.4	8.7	9.4	10.1	10.6	11.7	11.8	6.5	5.5	5.8
Sault Ste Marie, Mich.	3.4	3.8	4.1	4.0	4.1	3.8	4.0	4.7	5.0	6.0	7.0	8.6	10.6	11.2	11.5	12.3	11.9	10.3	8.9	6.9	5.9	4.7	4.2	3.9	6.7
Savannah, Ga.....	4.9	4.9	4.9	4.6	4.8	5.0	5.1	6.2	6.8	7.0	6.8	6.9	8.5	9.3	10.5	10.2	10.0	10.1	8.7	7.2	6.2	6.5	6.4	5.4	7.0
Seattle, Wash.....	2.8	2.5	2.0	1.5	2.0	1.7	1.7	1.6	1.5	2.1	2.4	3.5	4.1	5.0	5.0	5.5	6.0	5.9	6.4	6.3	6.3	6.0	4.9	3.3	3.7
Shreveport, La.....	4.8	4.5	4.4	4.2	4.0	3.3	3.4	4.1	5.7	7.0	6.0	6.0	5.9	6.0	6.1	6.6	6.8	6.3	6.4	5.0	3.7	4.2	4.5	4.2	5.1
Sioux City, Iowa.....	7.5	7.5	7.3	7.1	7.4	7.3	6.4	7.0	8.1	9.5	10.0	10.2	10.1	9.8	10.2	10.3	9.5	9.2	8.3	7.9	6.7	6.8	6.6	6.7	8.2
Spokane, Wash.....	3.5	3.4	3.0	3.4	3.2	2.8	3.3	3.3	3.6	3.9	5.4	6.4	6.2	6.2	6.7	6.6	7.2	7.0	7.0	6.8	6.5	5.5	4.6	4.3	5.0
Springfield, Ill.....	7.3	6.7	6.7	7.0	6.5	6.4	6.6	6.9	7.9	8.6	9.0	9.1	8.6	9.6	9.4	9.3	9.5	8.7	7.8	6.5	5.6	6.4	7.0	7.3	7.7
Springfield, Mo.....	7.6	8.0	7.5	7.6	7.6	7.7	7.5	7.5	8.0	9.4	10.5	10.7	9.9	9.4	9.3	8.6	8.9	8.7	7.4	6.9	6.0	7.1	7.1	7.5	8.2
Tampa, Fla.....	4.9	4.4	4.4	4.5	4.4	4.1	5.3	5.6	6.4	7.0	7.5	6.7	8.0	9.2	9.2	8.1	8.2	7.7	6.1	5.1	4.3	4.3	4.3	4.2	6.0
Tatoosh Island, Wash.	6.2	7.4	6.9	7.0	6.9	6.0	6.0	5.8	5.9	5.1	5.0	5.4	5.2	6.5	6.9	7.2	7.1	7.5	6.8	6.9	6.6	7.0	7.0	6.7	6.5
Toledo, Ohio.....	8.4	8.2	7.5	7.7	7.6	7.5	7.7	8.1	8.4	8.5	9.3	9.4	9.6	9.7	10.1	9.8	10.3	9.2	7.9	7.1	7.4	8.0	8.1	8.1	8.5
Vicksburg, Miss.....	6.4	5.8	5.7	5.5	5.3	5.1	5.5	5.5	5.9	5.9	5.4	5.0	5.9	6.5	6.8	7.0	7.3	7.5	5.9	5.5	5.1	5.2	5.5	6.1	5.9
Vineyard Haven, Mass.	7.8	7.3	7.3	7.6	7.1	7.0	7.0	7.7	8.6	8.8	9.1	9.0	8.8	9.2	9.1	8.9	8.3	8.1	7.5	7.6	7.4	7.9	7.7	8.0	8.0
Walla Walla, Wash.....	5.0	5.4	5.7	5.2	5.0	5.5	5.4	4.8	4.5	4.5	4.6	5.3	5.3	4.8	4.8	4.7	4.8	5.0	5.1	4.9	4.3	3.5	4.0	5.4	4.9
Washington, D. C.....	3.6	3.8	3.9	3.8	3.8	3.7	3.9	4.3	5.9	7.3	7.5	7.3	8.3	8.7	8.0	7.7	7.6	6.8	5.8	5.0	3.9	4.0	4.2	4.0	5.5
Wichita, Kans.....	5.3	5.1	5.2	4.7	4.3	4.0	4.0	4.9	5.5	5.7	7.1	7.5	8.0	8.6	8.9	8.9	8.9	7.9	6.9	5.5	5.0	4.4	5.1	4.9	6.1
Williston, N. Dak.....	5.5	4.8	4.7	4.8	4.0	4.2	4.0	3.9	4.8	6.5	7.8	8.0	8.5	9.3	9.9	10.4	10.4	9.8	9.0	9.0	7.7	6.3	5.7	5.7	6.9
Wilmington, N. C.....	7.0	6.9	6.7	6.9	6.2	5.5	5.5	6.7	7.5	7.4	8.7	9.5	10.2	11.1	11.2	11.4	11.7	10.5	9.7	8.1	7.6	7.1	7.3	7.3	8.2
Winnemucca, Nev.....	7.7	8.3	9.3	8.5	8.2	8.9	8.7	8.7	8.0	7.6	7.5	8.2	8.9	9.8	9.9	11.0	12.0	11.4	11.6	11.7	10.8	9.4	8.4	7.8	9.3
Woods Hole, Mass.....	12.7	13.4	13.4	12.8	11.7	11.5	11.4	12.5	13.2	14.4	14.0	14.2	14.2	14.4	14.3	14.8	13.7	13.2	13.0	13.0	12.7	13.7	13.9	14.2	13.3
Yuma, Ariz.....	7.5	6.3	5.4	4.7	4.3	3.8	3.6	4.0	4.2	5.3	6.1	7.1	8.0	8.4	7.6	7.5	7.9	8.5	10.1	10.5	10.6	9.2	7.8	7.0	6.9

TABLE VIII.—Heights of rivers above low-water mark, July, 1896.

Stations.	Distance to mouth of river.	Danger-point on gauge.	Highest water.		Lowest water.		Me'n stage.	Monthly range.	Stations.	Distance to mouth of river.	Danger-point on gauge.	Highest water.		Lowest water.		Me'n stage.	Monthly range.
			Height.	Date.	Height.	Date.						Height.	Date.	Height.	Date.		
<i>Mississippi River.</i>																	
St. Paul, Minn.....	Miles. 2,057	Feet. 14.0	Feet. 5.7	1	Feet. 1.8	31	Feet. 3.6	3.9	Louisa, Ky.....	Miles. 26	Feet.	Feet. 19.8	10	Feet. 5.1	6	Feet. 8.5	14.7
La Crosse, Wis.....	1,867	10.0	6.4	1	2.5	31	4.2	3.9	<i>Wabash River.</i>								
Dubuque, Iowa.....	1,759	15.0	7.0	1	2.6	31	4.4	4.4	Mount Carmel, Ill. . .	50	15.0	14.3	29-31	1.8	17-19	6.0	12.3
Davenport, Iowa.....	1,653	15.0	6.0	1	2.7	21	3.9	3.3	<i>Cumberland River.</i>								
Keokuk, Iowa.....	1,523	14.0	6.0	1,2	2.5	19, 21-23	4.0	3.5	Burnside, Ky.....	404	50.0	37.5	17	2.6	2	11.7	34.9
Hannibal, Mo.....	1,462	17.0	6.9	3	3.5	18	5.6	3.4	Nashville, Tenn.....	145	40.0	28.8	22	3.9	1	15.8	34.9
St. Louis, Mo.....	1,321	30.0	21.8	23	13.6	17	17.1	8.2	<i>Tennessee River.</i>								
Memphis, Tenn.....	910	33.0	24.5	29	13.4	1	17.2	11.1	Knoxville, Tenn.....	640	29.0	.....	.....	.....	.....	.....	.....
Helena, Ark.....	834	37.0	31.8	30	19.6	1	23.7	12.2	Chattanooga, Tenn.....	455	33.0	21.6	12	3.1	2	9.1	18.5
Arkansas City, Ark.....	702	42.0	32.4	31	20.4	2	23.9	12.0	Johnsonville, Tenn.....	94	21.0	16.0	16	2.2	4	8.0	13.8
Greenville, Miss.....	682	40.0	27.2	31	16.9	2, 3	19.8	10.3	<i>Arkansas River.</i>								
Vicksburg, Miss.....	541	41.0	27.2	31	18.5	5	20.9	8.7	Fort Smith, Ark.....	351	22.0	14.2	26	2.9	22, 23	6.4	11.3
New Orleans, La.....	108	13.0	6.9	1, 7	5.2	25, 26	5.9	1.7	Little Rock, Ark.....	176	23.0	14.3	28	2.5	26	7.5	9.8
<i>Missouri River.</i>																	
Pierre, S. Dak.*.....	1,132	13.1	9.1	9	5.8	30, 31	7.2	3.3	<i>Red River.</i>								
Sioux City, Iowa.....	902	18.7	13.4	1	10.4	29	11.7	3.0	Shreveport, La.....	449	29.2	0.0	16	— 1.8	9-12	— 1.1	1.8
Omaha, Nebr.....	667	18.0	13.5	1	10.7	25, 26	11.2	2.8	<i>James River.</i>								
Kansas City, Mo.....	386	21.0	19.1	6	12.6	25	15.7	6.5	Lynchburg, Va.....	251	18.0	10.6	10	0.4	3	2.1	10.2
<i>Ohio River.</i>																	
Parkersburg, W. Va.....	736	38.0	33.2	25	6.0	6	14.6	27.2	<i>Congaree River.</i>								
Callettsburg, Ky.....	682	50.0	38.5	27, 28	6.5	7	19.1	32.0	Columbia, S. C.....	.....	15.0	18.2	8	0.2	5	4.2	18.0
Cincinnati, Ohio.....	500	45.0	40.5	29	9.8	9	22.1	30.7	<i>Savannah River.</i>								
Louisville, Ky.....	368	24.0	14.1	31	6.4	10	9.4	7.7	Augusta, Ga.....	140	32.6	30.2	10	4.3	2, 4	10.6	25.0
Evansville, Ind.....	184	30.0	28.6	31	9.4	13	17.8	19.2	<i>Alabama River.</i>	215	48.0	9.3	12	0.2	4	3.5	9.1
Paducah, Ky.....	47	40.0	34.1	26	9.5	1	16.2	14.6	<i>Williamette River.</i>								
Cairo, Ill.....	1,140	40.0	34.0	26	21.3	1	25.8	12.7	Portland, Oreg.....	.....	15.0	23.5	3	13.0	31	20.3	10.5
<i>Monongahela River.</i>																	
Pittsburg, Pa.....	906	22.0	21.8	26	3.1	2	8.8	18.7	<i>Sacramento River.</i>								
<i>Great Kanawha River.</i>									Redbluff, Cal.....	.....	20.0	2.4	1	0.8	31	1.5	1.6
Charleston, W. Va.....	61	30.0	20.2	10	3.7	4	6.6	16.5	Sacramento, Cal.....	.....	28.0	18.2	1	11.7	31	14.5	6.5

TABLE IX.—Resultant winds from observations at 8 a. m. and 8 p. m., daily, during July, 1896.

Stations.	Component direction from—				Resultant.		Stations.	Component direction from—				Resultant.	
	N.	S.	E.	W.	Direction from—	Duration.		N.	S.	E.	W.	Direction from—	Duration.
<i>New England.</i>							<i>Upper Lake Region—Cont'd.</i>						
Eastport, Me.	15	30	7	23	s. 47 w.	22	Milwaukee, Wis.	21	18	21	19	n. 34 e.	4
Portland, Me.	11	29	8	27	s. 47 w.	26	Greenbay, Wis.	18	24	13	18	s. 40 w.	8
Northfield, Vt.	21	33	4	8	s. 18 w.	13	Duluth, Minn.	27	14	18	23	n. 21 w.	14
Boston, Mass.	14	23	11	29	s. 66 w.	30	<i>North Dakota.</i>						
Nantucket, Mass.	9	27	7	36	s. 58 w.	34	Moorhead, Minn.	28	23	8	8	n.	5
Woods Hole, Mass.*	2	22	6	9	s. 9 w.	30	Bismarck, N. Dak.	24	13	22	15	n. 22 e.	13
Block Island, R. I.	8	27	11	37	s. 54 w.	32	Williston, N. Dak.	22	23	21	8	s. 8 e.	13
New Haven, Conn.	18	29	9	24	s. 72 w.	16	<i>Upper Mississippi Valley.</i>						
<i>Middle Atlantic States.</i>							St. Paul, Minn.	20	23	16	22	s. 63 w.	7
Albany, N. Y.	12	29	7	22	s. 42 w.	23	La Crosse, Wis.†	7	19	2	6	s. 18 w.	13
New York, N. Y.	12	29	11	28	s. 45 w.	24	Davenport, Iowa	15	19	14	27	s. 73 w.	14
Harrisburg, Pa.	11	21	7	27	s. 63 w.	22	Des Moines, Iowa	18	26	17	12	s. 32 e.	9
Philadelphia, Pa.	15	28	4	26	s. 60 w.	26	Dubuque, Iowa	22	17	18	17	n. 11 e.	5
Baltimore, Md.	14	29	4	28	s. 58 w.	28	Keokuk, Iowa	20	22	13	19	s. 72 w.	6
Washington, D. C.	15	31	6	34	s. 48 w.	24	Calro, Ill.	18	22	11	12	s. 3 w.	17
Lynchburg, Va.	9	26	15	27	s. 35 w.	21	Springfield, Ill.	18	23	15	21	s. 50 w.	8
Norfolk, Va.	8	33	15	34	s. 20 w.	27	Hannibal, Mo.	13	25	9	21	s. 39 w.	19
<i>South Atlantic States.</i>							St. Louis, Mo.	15	33	11	15	s. 13 w.	18
Charlotte, N. C.	7	37	16	12	s. 8 e.	30	<i>Missouri Valley.</i>						
Hatteras, N. C.	6	38	9	28	s. 31 w.	37	Columbia, Mo.*	7	17	6	7	s. 6 w.	10
Kittyhawk, N. C.	10	31	9	33	s. 49 w.	32	Kansas City, Mo.	16	28	21	11	s. 40 e.	16
Raleigh, N. C.	8	31	9	27	s. 38 w.	29	Springfield, Mo.	9	34	18	11	s. 16 e.	26
Wilmington, N. C.	6	31	11	33	s. 40 w.	34	Omaha, Nebr.	21	29	22	13	s. 48 e.	12
Charleston, S. C.	3	43	9	22	s. 18 w.	42	Sioux City, Iowa†	11	14	10	2	s. 69 e.	8
Augusta, Ga.	14	23	13	25	s. 53 w.	15	Pierre, S. Dak.	16	18	28	10	s. 84 e.	18
Savannah, Ga.	2	42	11	15	s. 6 w.	40	Huron, S. Dak.	23	23	24	7	e.	17
Jacksonville, Fla.	2	38	21	12	s. 14 e.	37	<i>Northern Slope.</i>						
<i>Florida Peninsula.</i>							Havre, Mont.	26	13	14	19	n. 21 w.	14
Jupiter, Fla.	4	31	39	4	s. 52 e.	44	Miles City, Mont.	28	12	24	11	n. 39 e.	21
Key West, Fla.	2	18	50	1	s. 72 e.	52	Helena, Mont.	22	22	4	21	w.	17
Tampa, Fla.	19	11	33	12	n. 69 e.	22	Rapid City, S. Dak.	19	20	15	18	s. 72 w.	3
<i>Eastern Gulf States.</i>							Cheyenne, Wyo.	16	24	13	18	s. 32 w.	9
Atlanta, Ga.	17	17	17	25	w.	8	Lander, Wyo.	17	24	13	29	s. 66 w.	18
Pensacola, Fla.	15	26	14	25	s. 45 w.	16	North Platte, Nebr.	15	28	24	6	s. 54 e.	22
Mobile, Ala.	17	20	13	22	s. 72 w.	10	<i>Middle Slope.</i>						
Montgomery, Ala.	5	26	22	23	s. 3 w.	21	Denver, Colo.	24	22	14	16	n. 45 w.	3
Meridian, Miss.	13	37	15	13	s. 5 e.	24	Pueblo, Colo.	25	12	23	18	n. 20 e.	15
Vicksburg, Miss.	8	32	16	25	s. 21 w.	26	Concordia, Kans.	9	34	24	6	s. 36 e.	31
New Orleans, La.	12	30	22	15	s. 21 e.	19	Dodge City, Kans.	6	33	41	3	s. 54 e.	47
<i>Western Gulf States.</i>							Wichita, Kans.	8	38	30	4	s. 28 e.	34
Shreveport, La.	9	35	19	13	s. 13 e.	27	Oklahoma, Okla.	9	41	18	9	s. 16 e.	33
Port Smith, Ark.	10	15	37	8	s. 80 e.	29	<i>Southern Slope.</i>						
Little Rock, Ark.	15	27	20	18	s. 9 e.	12	Abilene, Tex.	7	47	18	4	s. 19 e.	42
Corpus Christi, Tex.	1	42	29	5	s. 30 e.	48	Amarillo, Tex.	6	45	8	7	s. 1 e.	39
Galveston, Tex.	4	45	8	18	s. 14 w.	42	<i>Southern Plateau.</i>						
Palestine, Tex.	2	42	18	3	s. 24 e.	36	El Paso, Tex.	18	13	31	16	n. 72 e.	16
San Antonio, Tex.	6	34	33	2	s. 48 e.	42	Santa Fe, N. Mex.	10	27	33	8	s. 56 e.	30
<i>Ohio Valley and Tennessee.</i>							Phoenix, Ariz.	5	27	9	32	s. 46 w.	32
Chattanooga, Tenn.	15	31	11	18	s. 24 w.	18	Yuma, Ariz.	13	24	16	28	s. 47 w.	16
Knoxville, Tenn.	15	12	13	35	n. 82 w.	22	<i>Middle Plateau.</i>						
Memphis, Tenn.	16	32	13	10	s. 17 e.	17	Carson City, Nev.	12	16	5	33	s. 82 w.	28
Nashville, Tenn.	9	35	18	18	s.	26	Winnemucca, Nev.	14	19	16	34	s. 58 w.	9
Lexington, Ky.	10	39	9	15	s. 12 w.	30	Salt Lake City, Utah.	12	24	24	17	s. 30 e.	14
Louisville, Ky.	16	35	12	12	s.	19	<i>Northern Plateau.</i>						
Indianapolis, Ind.	13	29	11	27	s. 45 w.	23	Baker City, Oreg.	24	28	4	17	s. 25 w.	26
Cincinnati, Ohio	15	29	14	21	s. 27 w.	16	Idaho Falls, Idaho	26	23	10	11	n. 18 w.	3
Columbus, Ohio	12	32	11	21	s. 27 w.	22	Spokane, Wash.	17	24	19	16	s. 23 e.	8
Pittsburg, Pa.	14	32	7	25	s. 45 w.	26	Walla Walla, Wash.	11	31	10	17	s. 19 w.	21
Parkersburg, W. Va.	11	31	12	13	s. 3 w.	20	<i>North Pacific Coast Region.</i>						
<i>Lower Lake Region.</i>							Fort Canby, Wash.	43	6	5	21	n. 23 w.	40
Buffalo, N. Y.	11	28	6	32	s. 57 w.	31	Port Angeles, Wash.*	4	20	5	40	s. 65 w.	38
Oswego, N. Y.	12	25	8	30	s. 60 w.	26	Seattle, Wash.	34	10	13	20	n. 16 w.	25
Rochester, N. Y.	9	22	7	33	s. 67 w.	34	Tatoosh Island, Wash.	4	37	9	37	s. 29 w.	38
Erie, Pa.	12	25	9	30	s. 59 w.	25	Portland, Oreg.	37	6	4	34	n. 44 w.	43
Cleveland, Ohio	17	26	19	16	s. 18 e.	10	Roseburg, Oreg.	44	1	20	14	n. 8 e.	43
Sandusky, Ohio	11	18	19	26	s. 45 w.	10	<i>Middle Pacific Coast Region.</i>						
Toledo, Ohio	12	18	12	30	s. 84 w.	18	Eureka, Cal.	26	17	2	39	n. 76 w.	38
Detroit, Mich.	18	23	13	24	s. 66 w.	12	Redbluff, Cal.	15	29	30	9	s. 56 e.	25
<i>Upper Lake Region.</i>							Sacramento, Cal.	3	45	9	26	s. 22 w.	45
Alpena, Mich.	23	18	15	24	n. 61 w.	10	San Francisco, Cal.	0	16	0	55	s. 74 w.	58
Grand Haven, Mich.	20	19	11	26	n. 86 w.	15	<i>South Pacific Coast Region.</i>						
Marquette, Mich.	26	11	13	28	n. 47 w.	22	Fresno, Cal.	31	3	4	44	n. 55 w.	49
Port Huron, Mich.	25	24	9	16	n. 82 w.	7	Los Angeles, Cal.	9	9	7	45	w.	38
Sault Ste. Marie, Mich.	19	12	16	28	n. 60 w.	14	San Diego, Cal.	23	11	5	42	n. 72 w.	39
Chicago, Ill.	20	17	20	18	n. 34 e.	4	San Luis Obispo, Cal.	17	21	1	32	s. 83 w.	31

* From observations at 8 p. m. only. † From observations at 8 a. m. only.

TABLE X.—Thunderstorms and auroras, July, 1896.

States.	No. of stations.																																Total.			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	No.	Days.		
Alabama.....	53	T.	2	1	4	...	2	3	1	...	1	...	1	1	4	4	4	2	2	2	...	3	...	...	...	...	...	...	2	5	44	19	T.	
Arizona.....	48	T.	1	...	4	2	4	2	1	2	1	3	3	2	3	3	1	3	3	3	2	3	2	3	3	1	3	...	1	1	60	26	A.	
Arkansas.....	51	T.	...	2	3	9	5	...	2	...	1	7	4	1	1	5	4	4	4	3	6	4	6	1	3	2	1	...	...	2	3	83	24	T.
California.....	197	T.	...	1	6	9	1	1	1	4	9	1	3	1	2	8	2	2	2	4	...	1	...	1	5	14	3	5	3	1	90	25	A.	
Colorado.....	70	T.	7	4	9	2	2	3	9	7	4	5	2	1	5	6	12	9	11	4	5	1	5	10	9	9	9	4	8	4	2	7	175	30	T.	
Connecticut.....	22	T.	...	4	2	9	1	6	...	...	...	1	...	8	...	3	2	...	...	...	1	...	4	3	1	...	9	...	1	11	66	16	A.	
Delaware.....	6	T.	...	2	...	1	2	1	...	1	...	3	1	1	...	2	2	...	...	...	2	1	1	2	...	1	4	...	4	3	31	17	T.	
Dist. of Columbia	4	T.	1	...	1	1	1	1	...	1	...	1	...	1	1	1	1	1	1	9	0	T.	
Florida.....	38	T.	6	6	3	3	6	9	9	3	3	3	3	...	4	2	1	7	8	4	1	4	2	6	4	...	2	4	2	4	6	11	126	28	A.	
Georgia.....	49	T.	3	2	2	...	1	5	3	1	1	1	1	2	4	2	4	7	1	2	1	1	2	4	...	1	2	4	2	1	1	1	2	64	29	A.
Idaho.....	36	T.	3	3	4	4	5	6	7	13	7	2	3	3	...	2	...	1	2	4	6	5	80	18	T.	
Illinois.....	97	T.	1	5	17	13	1	4	1	1	6	9	17	3	...	3	22	10	18	6	23	13	4	15	17	5	1	7	18	239	25	A.	
Indiana.....	48	T.	1	2	3	7	1	...	1	...	...	3	3	8	13	...	...	...	5	...	3	1	7	6	...	3	6	5	...	4	...	82	19	T.
Indian Territory.	6	T.	...	1	1	...	...	...	...	...	...	...	...	1	1	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	5	0	A.
Iowa.....	101	T.	5	16	19	1	...	2	...	...	5	...	1	2	17	1	3	4	1	...	20	8	13	3	4	19	12	10	3	1	31	201	23	T.
Kansas.....	73	T.	7	5	6	8	...	5	2	6	5	1	...	2	...	7	3	9	12	5	2	2	3	9	4	2	...	2	4	6	3	4	124	27	A.	
Kentucky.....	47	T.	4	5	4	8	4	2	1	...	1	4	4	3	8	5	...	...	3	6	3	1	5	1	1	...	1	1	3	2	...	80	24	T.
Louisiana.....	48	T.	6	6	4	5	6	6	5	1	1	2	3	2	2	...	2	3	9	2	5	3	...	1	1	...	1	1	...	1	...	78	24	A.		
Maine.....	16	T.	...	...	3	1	...	...	...	...	5	...	6	...	5	...	1	2	...	...	1	2	...	...	...	...	...	...	1	...	...	26	9	T.
Maryland.....	31	T.	1	4	2	3	6	1	...	3	1	3	2	...	6	1	...	...	...	2	4	...	7	...	...	10	4	7	7	1	...	75	30	A.
Massachusetts...	77	T.	1	1	4	7	2	9	...	...	4	...	8	2	18	3	...	...	2	1	7	...	...	...	2	10	2	...	...	...	79	16	T.	
Michigan.....	96	T.	3	2	3	5	...	...	...	...	1	5	10	12	8	...	...	3	1	2	6	...	2	...	20	7	2	5	1	...	97	18	A.	
Minnesota.....	69	T.	14	4	...	1	1	...	1	...	1	8	12	9	...	1	8	1	11	1	10	1	1	...	6	7	...	3	4	...	102	19	T.			
Mississippi.....	52	T.	2	2	2	3	6	3	1	1	1	2	5	...	1	1	1	3	7	6	3	2	1	3	2	...	1	...	1	3	...	63	25	A.		
Missouri.....	96	T.	10	13	19	12	2	9	...	...	9	8	5	31	11	13	25	17	15	19	13	8	2	7	1	4	6	4	3	9	...	275	25	T.
Montana.....	40	T.	5	5	...	5	1	...	1	2	5	...	2	1	2	1	...	2	2	...	2	2	...	2	2	...	4	...	1	...	...	43	17	A.
Nebraska.....	112	T.	6	1	6	1	...	5	...	8	2	...	1	6	1	4	2	1	3	3	3	8	...	7	12	4	10	3	10	12	...	130	24	T.		
Nevada.....	39	T.	...	4	6	...	1	7	4	7	8	3	...	1	10	8	3	1	2	2	3	3	4	5	7	4	3	...	4	...	...	100	23	A.
New Hampshire..	23	T.	...	1	2	2	...	4	...	1	...	1	...	4	1	10	...	...	3	2	...	...	...	...	4	5	4	...	...	...	43	13	T.	
New Jersey.....	54	T.	...	2	9	11	15	8	1	7	8	...	1	8	5	10	6	...	4	6	20	2	5	...	3	24	17	15	12	...	199	23	A.			
New Mexico.....	36	T.	2	4	4	1	2	1	...	1	1	4	3	2	3	3	2	3	3	1	1	3	1	2	6	3	1	1	2	2	3	2	67	29	T.	
New York.....	93	T.	...	11	11	5	8	4	...	4	...	1	12	2	9	3	...	...	6	3	12	2	2	...	1	11	11	16	12	1	...	137	23	A.
North Carolina..	60	T.	2	9	15	9	12	21	11	14	7	12	7	17	6	2	8	13	2	2	3	1	10	9	1	3	11	4	7	5	7	6	241	31	T.	
North Dakota...	30	T.	2	2	...	1	2	...	1	1	2	2	1	1	3	1	2	...	6	...	1	1	...	...	1	...	4	1	...	...	...	32	17	A.
Ohio.....	140	T.	2	31	12	27	12	6	4	3	5	...	1	10	32	39	45	2	...	22	22	8	22	7	19	...	30	44	30	25	32	482	26	T.		
Oklahoma.....	30	T.	...	5	1	...	...	2	...	...	...	1	...	...	...	...	1	1	2	...	1	...	...	...	...	...	...	1	1	...	...	13	7	A.
Oregon.....	60	T.	1	...	1	2	2	...	2	1	...	4	2	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	16	9	T.
Pennsylvania....	93	T.	1	1	5	10	7	14	9	2	12	4	...	9	3	12	2	...	6	1	17	1	3	...	2	30	17	23	11	...	202	24	A.			
Rhode Island...	6	T.	...	1	...	...	...	1	...	...	...	1	...	2	...	1	...	...	2	2	...	...	...	...	...	...	1	...	...	...	...	9	6	T.
South Carolina..	42	T.	...	5	3	1	4	9	3	1	2	2	...	1	8	2	2	8	2	2	1	1	5	2	...	1	5	3	2	5	3	4	4	91	28	A.
South Dakota....	46	T.	2	4	2	...	...	2	2	...	2	...	1	1	...	2	1	...	3	3	2	1	1	2	...	4	1	3	1	3	4	45	30	T.
Tennessee.....	49	T.	6	5	7	7	5	6	5	...	1	4	8	7	6	11	13	2	1	...	2	5	3	1	3	7	3	3	...	1	5	5	132	27	A.	
Texas.....	91	T.	2	4	3	9	8	6	1	...	4	6	9	7	2	2	2	3	1	4	1	2	1	1	...	1	1	1	...	1	1	...	84	27	T.	
Utah.....	32	T.	...	1	2	2	2	1	5	1	...	4	9	8	2	2	6	...	1	...	1	3	4	2	3	2	7	2	...	1	...	71	23	A.		
Vermont.....	13	T.	...	4	1	2	1	1	...	...	1	...	3	...	6	...	...	...	...	...	...	...	...	...	...	...	2	...	2	1	...	81	13	T.
Virginia.....	37	T.	1	11	3	3	7	5	2	1	1	3	8	1	7	6	2	1	...	2	3	9	...	8	1	1	1	2	6	3	...	98	26	A.		
Washington.....	51	T.	1	...	1	...	...	1	...	...	2	2	...	1	...	...	...	...	...	2	...	...	1	1	...	...	...	...	...	...	...	11	8	T.
West Virginia...	37	T.	1	3	4	1	1	4	1	1	1	...	3	3	1	5	6	...	...	2	2	7	2	7	1	1	3	4	3	9	...	76	25	A.
Wisconsin.....	58	T.	4	...	18	...	6	...	...	...	1	7	8	16	4	...	...	...	1	1														

TABLE XI.—Hourly sunshine as deduced from sunshine recorders, July, 1896.

Stations.		Instrument.	Percentages for each hour of local mean time ending with the respective hour.																Monthly summary.			
			A. M.								P. M.								Instrumental record.			
																			Actual.	Possible.	Per cent of possible.	Personal estimate.
			5	6	7	8	9	10	11	Noon	1	2	3	4	5	6	7	8	Hours.	Hours.		
Atlanta, Ga.	T.	17	2	6	10	24	36	50	55	62	60	57	52	46	16	1	4	148.4	439.7	34	47	
Baltimore, Md.	T.	50	45	41	49	54	63	63	61	66	67	62	55	37	25	11	11	219.5	453.0	48	37	
Bismarck, N. Dak.	P.	52	48	57	70	70	68	65	67	66	64	67	66	66	64	60	58	304.1	479.6	63	59	
Boston, Mass.	T.	30	35	37	46	52	56	60	60	63	68	63	54	53	46	44	25	225.3	461.8	51	46	
Buffalo, N. Y.	T.	8	30	59	73	81	82	85	85	91	88	85	83	76	67	47	27	322.4	465.2	69	41	
Chicago, Ill.	T.	34	37	45	51	67	76	81	75	82	85	84	77	73	63	51	51	305.7	461.8	66	58	
Cincinnati, Ohio	T.	56	54	63	70	82	90	96	96	98	93	88	83	82	81	64	54	365.0	453.0	81	54	
Cleveland, Ohio	P.	46	44	50	63	64	62	61	64	64	69	67	72	60	54	39	44	270.2	461.8	59	46	
Columbus, Ohio	T.	8	13	21	48	57	65	73	72	70	69	63	63	50	30	10	9	220.0	455.2	48	37	
Denver, Colo.	P.	47	47	73	80	79	80	88	85	80	63	55	50	45	42	29	28	285.4	455.2	63	53	
Des Moines, Iowa	T.	65	66	65	58	62	66	66	73	64	73	61	53	51	55	60	64	288.5	461.8	62	59	
Detroit, Mich.	T.	29	29	44	58	72	72	75	79	83	83	79	74	64	63	43	42	295.1	461.8	64	59	
Dodge City, Kans.	P.	36	51	61	65	65	70	73	75	71	71	70	68	61	60	43	38	285.7	450.1	63	55	
Dubuque, Iowa	T.	5	11	42	62	67	82	85	90	87	86	87	83	77	72	61	54	317.2	461.8	69	44	
Eastport, Me.	P.	19	33	34	42	49	59	60	62	62	64	64	58	60	52	43	43	239.5	471.7	51	40	
Eureka, Cal.	P.	0	4	10	15	23	29	42	58	61	65	66	59	45	34	27	15	169.6	458.6	37	39	
Fresno, Cal.	T.	81	81	79	84	89	91	93	95	97	97	94	94	96	93	88	86	405.3	447.4	91	88	
Galveston, Tex.	P.	43	43	71	73	80	84	91	95	95	95	96	91	88	88	65	25	354.5	427.4	83	68	
Helena, Mont.	P.	61	62	70	70	78	81	82	79	76	81	77	73	72	71	64	60	348.3	479.6	73	67	
Kansas City, Mo.	P.	53	45	55	65	68	72	70	67	67	61	72	68	61	50	55	58	277.8	453.0	61	52	
Little Rock, Ark.	T.	52	60	65	75	88	94	99	99	96	92	89	89	80	77	68	64	368.7	442.0	83	54	
Louisville, Ky.	T.	62	65	65	68	72	83	88	88	89	90	87	81	69	61	52	49	326.3	450.1	75	51	
Minneapolis, Minn.	T.	23	29	55	66	77	78	76	82	84	85	82	76	70	64	36	24	306.7	471.7	65	55	
New Orleans, La.	T.	44	57	83	79	73	73	72	75	79	79	64	63	67	56	28	36	282.9	429.6	66	65	
New York, N. Y.	T.	19	23	35	50	56	59	68	71	79	75	71	63	54	45	23	15	243.6	458.6	53	54	
Northfield, Vt.	P.	3	10	34	49	55	53	58	57	56	63	57	55	51	37	23	23	308.9	468.4	45	35	
Philadelphia, Pa.	T.	54	58	58	64	71	84	89	94	92	91	88	87	79	59	35	27	333.3	455.2	73	57	
Phoenix, Ariz.	P.	57	56	62	66	74	75	75	82	85	88	85	83	80	63	52	30	310.0	437.2	73	50	
Portland, Me.	T.	3	11	36	55	70	78	86	85	87	83	79	75	69	60	31	5	281.3	468.4	60	37	
Portland, Oreg.	T.	90	82	74	73	80	79	86	89	90	96	95	91	90	92	90	91	411.7	475.7	87	82	
Do.	P.	90	82	76	77	81	81	85	88	91	96	95	91	93	92	90	91	414.1	475.7	87	82	
Rochester, N. Y.	T.	38	41	57	61	72	72	75	76	79	77	83	73	67	57	39	33	299.2	465.2	64	58	
St. Louis, Mo.	T.	34	39	54	77	81	78	81	82	83	89	84	76	78	68	52	49	325.5	463.0	72	56	
Salt Lake City, Utah.	P.	58	57	71	75	82	83	79	78	71	75	75	77	73	60	50	49	324.5	458.6	71	40	
San Diego, Cal.	P.	0	22	20	27	49	61	66	85	88	85	84	76	70	68	60	60	272.5	437.2	62	66	
San Francisco, Cal.	T.	44	36	40	52	69	90	95	96	99	98	96	97	91	64	52	52	341.2	450.1	76	67	
Santa Fe, N. Mex.	P.	35	48	60	66	74	75	74	75	66	64	55	35	31	28	25	17	242.4	444.3	55	37	
Savannah, Ga.	P.	10	53	63	67	62	69	73	63	70	72	65	70	63	46	18	13	263.4	494.5	61	46	
Vicksburg, Miss.	T.	33	61	65	86	97	97	100	97	100	100	100	100	90	82	75	70	387.8	494.5	89	85	
Washington, D. C.	P.	26	34	40	45	60	59	63	61	70	68	57	65	54	39	32	32	257.1	463.0	52	40	
Wilmington, N. C.	T.	0	9	18	61	74	78	79	80	84	86	70	67	61	33	19	14	254.4	439.7	58	42	

TABLE XII.—Maximum rainfall in one hour or less, July, 1896.

Stations.	Maximum rainfall in—					
	5 min.	Date.	10 min.	Date.	1 hour.	Date.
	Inch.		Inch.		Inch.	
Atlanta, Ga.	0.35	6	0.47	6	0.67	6
Baltimore, Md.	0.30	12	0.45	12	1.30	21
Bismarck, N. Dak.	0.05	12	0.09	12	0.13	12
Boston, Mass.	0.34	15	0.27	15	0.42	15
Buffalo, N. Y.	0.12	20	0.34	20	0.95	20
Chicago, Ill.	0.15	26	0.30	26	0.64	26
Cincinnati, Ohio	0.30	20	0.48	20	1.23	20
Cleveland, Ohio	0.19	13	0.31	19	0.67	19
Denver, Colo.	0.35	16, 25	0.60	25	1.04	16
Detroit, Mich.	0.38	26	0.50	26	1.78	26
Dodge City, Kans.	0.25	18	0.45	19	1.16	18
Duluth, Minn.	0.09	19	0.15	19	0.36	19
Eastport, Me.	0.15	23	0.25	23	0.36	23
Galveston, Tex.	0.30	11	0.45	11	1.23	11
Indianapolis, Ind.	0.19	19	0.25	29	0.60	19
Jacksonville, Fla.	0.23	8	0.37	6	0.52	8
Jupiter, Fla.	0.35	10	0.44	10	1.18	10
Kansas City, Mo.	0.40	18	0.75	18	2.30	18
Key West, Fla.	0.30	4	0.36	4	0.53	4
Little Rock, Ark.	0.07	15	0.08	15	0.26	15
Louisville, Ky.	0.55	4	1.05	4	2.70	4
Memphis, Tenn.	0.06	18	0.09	18	0.32	18

TABLE XII.—Maximum rainfall—Continued.

Stations.	Maximum rainfall in—					
	5 min.	Date.	10 min.	Date.	1 hour.	Date.
	Inch.		Inch.		Inch.	
Milwaukee, Wis.	0.10	26	0.12	26	0.35	26
Nantucket, Mass.	0.25	6	0.40	6	1.15	6
Nashville, Tenn.	0.32	12	0.58	12	1.27	12
New Orleans, La.	0.31	10	0.50	10	0.94	10
New York, N. Y.	0.40	23	0.58	23	1.04	6
Norfolk, Va.	0.35	16	0.53	16	1.03	16
Omaha, Nebr.	0.28	31	0.25	31	0.35	17
Philadelphia, Pa.	0.27	29	0.32	29	0.64	27
Portland, Me.	0.22	11	0.31	11	0.48	11
Portland, Oreg.	0.12	15	0.22	29	0.70	29
Rochester, N. Y.	0.25	21	0.40	21	0.85	21
St. Louis, Mo.	0.30	14	0.23	14	0.28	14
St. Paul, Minn.	0.05	13	0.10	13	0.30	13
Salt Lake City, Utah	0.05	13	0.10	13	0.30	13
San Diego, Cal.	0.40	7	0.70	7	1.16	7
San Francisco, Cal.	0.40	7	0.70	7	1.16	7
Savannah, Ga.	0.30	4	0.25	4	0.32	4
Seattle, Wash.	0.30	9	0.29	9	0.43	21
Vicksburg, Miss.	0.21	11	0.32	11	0.52	7
Washington, D. C.	0.21	11	0.32	11	0.52	7
Wilmington, N. C.	0.21	11	0.32	11	0.52	7

* Less than 0.05 inch in one hour.

TABLE XIII.—Excessive precipitation, by stations, for July, 1896.

Stations.	Monthly rainfall 10 inches, or more.	Rainfall 2.50 inches, or more, in 24 hours.		Rainfall of 1 inch, or more, in one hour.		
		Amt.	Day.	Amt.	Time.	Day.
<i>Alabama.</i>						
Alco.....	10.02	4.28	7	Ins.	A. m.	
Do.....		2.72	17			
Brewton.....		5.75	7			
Elba.....		3.01	7			
Eufaula.....	10.25					
Evergreen.....		4.31	6-7			
Do.....		2.92	16-17			
Fort Deposit.....		2.62	6-7			
Lock No. 4.....		4.09	6-7			
Maple Grove.....		3.00	15-16	1.35	1 00	15
Marion.....		4.68	15-16			
Mobile.....	12.30	3.26	17	1.23	0 45	30
Newton.....	12.57	6.62	7	1.50	1 00	16
Oneonta.....		4.21	7			
Tuscaloosa.....				1.06	0 45	15
Union Springs.....		3.93	7-8			
<i>Arizona.</i>						
Fort Huachuca.....				1.55	1 30	18
Mount Huachuca.....		2.60	23	2.60	1 15	23
Oro Blanco.....				1.12	0 30	20
Payson.....		2.60	15			
San Carlos.....				2.10	1 00	6
<i>Arkansas.</i>						
Corning.....		2.85	24	2.85	0 55	24
Keesees Ferry.....		2.56	22	2.56	1 35	22
Kirby.....				1.80	1 00	4
Lonohe.....				1.38	0 40	4
Do.....				1.00	0 30	5
Marvell.....				1.02	0 45	5
Mossville.....		2.56	22			
Prescott.....				1.63	0 30	11
<i>Colorado.</i>						
Denver.....				1.04	0 53	16
Do.....				1.02	0 28	25
Greeley.....				2.35	1 30	17
<i>Delaware.</i>						
Seaford.....		3.00	27-28	3.00	2 15	27-28
<i>Florida.</i>						
Brooksville.....	11.30	2.60	8	1.02	0 10	28
Clermont.....		3.00	7-8			
Emerson.....	11.23					
Fort Meade.....	11.32					
Jupiter.....				1.18	1 00	10
Kissimmee.....		3.63	18			
Lake City.....	10.87					
Manatee.....	14.36	2.62	9			
Milton.....	19.97	9.05	7			
Mullet Key.....		3.20	8			
Orlando.....	10.66	3.13	1	3.00	1 00	1
Pensacola.....	11.76	5.01	7			
Quincy.....	10.40	2.80	7-8	1.83	1 30	15
Tallahassee.....	10.51	4.70	7			
Tampa.....	12.30	2.84	17-18	2.60	1 45	18
Tarpon Springs.....		3.76	8			
<i>Georgia.</i>						
Albany.....				1.60	0 45	18
Allentown.....		2.85	7-8			
Americus.....		3.02	7-8			
Athens.....	10.31	5.91	8-9			
Atlanta.....		3.26	7-8			
Augusta.....		5.65	6-7	2.20	1 37	6
Do.....				1.36	1 00	7
Blakely.....	12.52	3.00	7			
Camak.....	10.63	3.70	7-8	1.44	1 10	3
Canton.....		2.78	7-8			
Clayton.....	11.11	4.21	8			
Columbus.....	10.35					
Diamond.....	11.31			1.12	0 45	15
Eastman.....						
Elberton.....		4.06	6-7			
Fort Gaines.....		3.55	8			
Gainesville.....	10.61	2.60	7-8	1.08	0 30	27
Gillsville.....		2.80	9			
Hephzibah.....		3.00	6			
Lagrange.....	11.05	4.22	7			
Lumpkin.....		4.75	10			
Macon.....		2.90	7-8			
Marietta.....				1.15	1 00	22
Marshallville.....	12.56	4.10	7	4.10	4 00	7
Do.....		3.15	17			
Milledgeville.....		3.96	6-7			
Newnan.....	10.14	4.50	8			
Point Peter.....		4.70	7			
Quitman.....	12.04			1.08	0 35	7
Do.....		4.85	10	4.85	1 50	10
Savannah.....				1.16	1 00	7
Talbotton.....		5.30	8			
Thomasville.....		3.05	7-8			
Toccoa.....	13.10	5.65	8-9			
Do.....		2.52	27			
Union Point.....	10.10					
Washington.....	11.94	6.57	7-8			
Waycross.....	10.81	3.08	9	3.06	3 00	9
Westpoint.....		3.15	8			
<i>Illinois.</i>						
Albion.....		3.51	20			
Alexander.....		2.97	19			
Do.....		3.05	24			
Atlanta.....		5.23	19			
Atwood.....	12.14	2.50	4			

TABLE XIII.—Excessive precipitation—Continued.

Stations.	Monthly rainfall 10 inches, or more.	Rainfall 2.50 inches, or more, in 24 hours.		Rainfall of 1 inch, or more, in one hour.		
		Amt.	Day.	Amt.	Time.	Day.
Illinois—Continued.						
Atwood.....		2.71	19			
Beardstown.....	13.52	9.33*	19-20			
Bloomington.....				1.15	1 00	31
Bushnell.....		2.55	19			
Carlinville.....				1.67	0 16	31
Carlyle.....		4.33	20			
Cattlin.....		2.60	19			
Cazenovia.....		2.85	19			
Charleston.....	10.04	3.41	3			
Cisne.....		3.77	20			
Clear Creek.....		2.80	17-18			
Do.....		3.50	20-21	1.33	0 50	23
Decatur.....		2.85	19			
Duquoin.....		2.75	20			
East Peoria.....		2.55	18			
Friend Grove.....		3.30	19-20			
Galva.....		4.01	23-24			
Griggsville.....		3.08	19			
Halliday.....		3.03	19			
Havana.....		2.55	19			
Iron.....		2.71	20			
Jordans Grove.....		3.61	20			
Knoxville.....		2.87	18-19			
Lexington.....		2.96	19			
Loami.....		2.50	24			
Louisville.....		4.22	19-20			
McLeansboro.....		2.89	19-20			
Martinsville.....	10.57	3.50	23-24			
Martinton.....		2.54	19			
Mascoutah.....		2.70	19			
Mattoon.....	10.07	3.26	3			
Minonk.....		2.55	18-19			
Mount Pulaski.....		2.96	19			
Mount Vernon.....		6.07	19-20	2.48	0 20	20
New Burnside.....				1.88	1 25	4
Olney.....		3.79	19-20			
Ottawa.....		3.33	23-24			
Palestine.....		3.43	19-20			
Piper City.....		3.38	22			
Plumhill.....		3.63	19-20			
Rantoul.....		3.40	19-20			
Riley.....				1.47	1 00	27
Rose Hill.....		3.30	19-20	1.00	0 50	20
Rushville.....		4.50	18-19			
St. Charles.....		2.80	26			
St. John.....		3.96	20			
Scales Mound.....		5.28	26			
Springfield.....		2.56	3-4			
Do.....		2.63	19			
Winnebago.....				1.70	1 00	26
Indiana.						
Anderson.....		3.34	28	1.01	1 00	28
Angola.....	12.78	2.87	19-20			
Auburn.....		2.53	20			
Bloomington.....		2.60	22-23			
Butlerville.....		4.12	21			
Columbia City.....	12.20	2.60	19			
Do.....		3.15	22	3.15	3 00	22
Columbus.....		3.08	20			
Delphi.....		3.16	19-20			
Evansville.....		2.75	20-21			
Farmland.....	11.88					
Greencastle.....		2.50	19			
Huntington.....	11.08	3.61	19	1.00	0 50	20
Indianapolis.....		2.95	19-20			
Jeffersonville.....	10.75	3.63	4			
Do.....		3.71	20-21			
Kokomo.....		3.08	27-28			
Lafayette.....	10.73	4.00	20-21	1.00	1 00	13
Lafayette.....		4.52	27-28			
Logansport.....		2.50	20			
Mauzy.....		2.97	20-21			
Northfield.....		3.77	26-27			
Rockville.....		3.25	20			
South Bend.....		3.47	19-20			
Syracuse.....		3.55	19-20			
Terra Haute.....		4.45	19-20			
Tipton.....	11.99	6.50	28			
Iowa.						
Afton.....		2.93	23	1.35	1 00	31
Amana.....	10.20	2.70	17-18			
Audubon.....		2.75	31			
Bonaparte.....		3.00	31			
Centerville.....	10.40	3.10	24			
Chariton.....		3.10	23			
Clarinda.....		3.46	17-18			
Clinton.....				2.30	2 00	21
College Springs.....		4.16	17-18			
Corning.....		2.87	18			
Delaware.....		3.54	26			
Dubuque.....		4.82	26	1.00	0 35	26
Eldora.....		4.70	26			
Gardengrove.....		3.21	23			
Greenfield.....	11.93	2.76	17-18			
Do.....		2.69	31			
Grundy Center.....	10.10	3.32	26			
Guthrie Center.....		2.75	23			
Hopeville.....	10.44	3.08	2			
Do.....		3.58	23			
Independence.....		3.65	26			

TABLE XIII.—Excessive precipitation—Continued.

Stations.	Monthly rainfall 10 inches, or more.	Rainfall 2.50 inches, or more, in 24 hours.		Rainfall of 1 inch, or more, in one hour.		
		Amt.	Day.	Amt.	Time.	Day.
<i>Iowa—Continued.</i>		<i>Inches.</i>	<i>Inches.</i>	<i>Ins.</i>	<i>A. m.</i>	
Iowa City		3.10	18			
Knoxville		2.98	23			
Larrabee				1.95	1 00	26
Logan		4.00	31			
Madrid		3.30	31			
Malvern				1.33	0 30	31
Maquoketa				2.20	2 00	22
Maxon		2.90	24			
Montezuma	10.97	3.00	25			
Do		3.16	31			
Moosau	12.67	3.50	18			
Do		3.05	31			
Newton	10.73	2.53	18			
Do		3.60	31			
Oskaloosa	10.60	3.61	23			
Oskaloosa	10.31			1.35	1 15	21
Do				2.00	1 40	31
Ottumwa		2.29	23-23			
Panama		3.18	31			
Portsmouth		3.50	31			
Seymour				2.00	2 00	23
Sidney		5.16	18			
Sioux City				1.35	0 45	26
Stuart		3.87	31			
Washington				1.12	0 30	31
Wauke	11.73	2.92	31			
Wauke		2.68	26			
Waverly		3.25	18			
Winterset	11.37					
<i>Kansas.</i>						
Abilene		7.35	17-18			
Asaria		4.30	17-18			
Beloit		3.25	22			
Blaine		2.96	17-18			
Colby				1.08	0 35	27
Columbus		2.50	19			
Do		3.61	21			
Concordia		4.64	17-18	1.62	1 00	17
Do				1.58	1 00	28
Cunningham		3.30	18			
Delphos		2.75	17-18			
Dodge City				1.16	1 00	18
Fort Riley		5.01	17-18			
Frankfort		3.95	1			
Do		3.00	18			
Grainfield				1.80	1 00	15
Do				2.15	2 00	21
Horton		2.87	18-19			
McPherson		4.40	18			
Manhattan		2.63	18			
Minneapolis		4.42	17-18			
Mount Hope		3.00	15-16			
New England Ranch		2.57	8			
Olathe		3.30	18			
Phillipsburg		2.95	4			
Salina		4.66	17-18			
Topeka		2.75	17-18			
Wakarusa	10.95	7.48	17-18			
<i>Kentucky.</i>						
Alpha	10.35	3.10	15-16			
Caddo		2.80	20-21			
Edmonton		2.60	16			
Falmouth		2.92	20-21			
Frankfort	10.38	4.25	30			
Franklin		4.10	3-5			
Greendale		3.08	20-21			
Harrods Creek	12.85	3.25	20			
Lexington	10.39	2.95	20-21			
Louisville	13.01	5.50	4	2.70	1 00	4
Do		4.19	20-21	1.29	1 00	21
Marrowbone		2.51	15-16			
Maysville		3.15	21			
Middlesboro	10.27					
Owensboro		3.71	20-21			
Pleasure Ridge Park		5.88	20-21			
Sandy Hook	10.80					
Shelby City	10.92	3.17	16-17			
Shelbyville	12.32	7.15	20-21			
Vanceburg		2.90	20-21			
<i>Louisiana.</i>						
Amite		3.06	4	3.06	1 35	4
Franklin				1.15	0 55	22
Do				1.65	0 45	20
Grand Coteau		2.50	30	2.50	1 45	30
Hammond				1.47	1 00	18
Southern University				1.00	1 00	1
Sugar Experiment Station				1.00	0 05	3
<i>Maryland.</i>						
Baltimore				1.30	1 00	21
Boethelville		2.50	24			
Cherryfields		3.74	6			
Deerpark	13.65	4.10	24			
Grantsville	10.17	2.70	24			
Laurel		2.50	7			
Princess Anne		2.61	6			
Sharpsburg		2.62	22-23			
Sunnyside		3.20	20			
<i>Massachusetts.</i>						
Dudley				1.30	1 00	3
Nantucket				1.15	1 00	6

TABLE XIII.—Excessive precipitation—Continued.

Stations.	Monthly rainfall 10 inches, or more	Rainfall 2.50 inches, or more, in 24 hours.		Rainfall of 1 inch, or more, in one hour.		
		Amt.	Day.	Amt.	Time.	Day.
<i>Michigan.</i>						
Allegan	<i>Inches.</i>	<i>Inches.</i>		<i>Ins.</i>	<i>A.m.</i>	
Birmingham	4.52	26-27				
Detroit	2.50	26-27				
Hanover	2.70	26-27		1.78	1 00	26
Hastings	2.50	19-20				
Howell	2.70	26-27				
Lansing	4.05	26-27				
Olivet	3.70	26				
Do	3.27	15		3.27	2 30	15
Pontiac	2.77	26				
South Haven	3.34	26-27				
	3.83	26				
<i>Minnesota.</i>						
Bird Island				1.26	1 05	2
Granite Falls				1.10	0 55	2
Worthington	3.40	23				
<i>Mississippi.</i>						
Bay St. Louis	2.52	19		1.64	1 00	17
Logtown				1.50	1 00	11
Woodville				1.45	1 00	18
Do						
<i>Missouri.</i>						
Brunswick		3.20	19			
Cowgill		4.68	18			
Downing	14.98	4.75	23			
Eldon		2.64	21			
Elmira		4.00	18			
Fairport		3.67	18			
Fayette		4.40	15	4.40	2 45	18
Fulton		2.95	20			
Gallatin		3.80	3-4			
Do		3.30	18-19			
Gorin	12.27	2.80	18			
Do		3.83	23			
Hannibal		5.45	18-19	1.20	1 00	19
Ironton		2.65	20-21			
Kansas City		5.62	18-19	2.30	1 00	18
Kidder		2.84	18-19			
Lamar		2.82	21			
Lebanon		3.05	16-17			
Liberty		5.50	18-19			
McCune		2.60	2			
Marceline				1.51	1 00	15
New Madrid	2.59	4		2.79	1 40	4
Do				2.32	1 00	22
Oakfield	2.99	19-20		1.28	0 36	31
Oskola	3.10	19				
Oto				2.00	2 00	15
Palmyra	12.24	6.02	19			
Platte River		3.12	18			
Potosi		2.88	20			
Princeton	10.81	2.60	2			
Do		3.96	18-19			
Richmond		2.52	18-19			
Sarco		2.90	21			
Shelbina	14.50	8.00	19			
Steffenville	11.18	4.23	19			
Sublett		2.50	19			
Unionville		2.77	23-24	2.02	0 54	3
<i>Nebraska.</i>						
Agree		2.50	8			
Arberville		3.35	30-31			
Aurora		4.44	31			
Beatrice		2.78	1			
Crete		3.60	1			
David City		4.75	30-31			
Elba				1.21	1 10	9
Freemont		4.32	31			
Nemaha		3.25	18			
Oakdale		2.61	8-9			
Odell		4.55	1			
Oseola		3.25	31			
Republican		2.80	28	2.80	1 15	28
Schuyler		2.95	31			
Thedford		2.60	30	2.60	1 45	30
Wakefield		3.29	31			
Wallace		2.97	15			
Wilber		4.50	1			
<i>Nevada.</i>						
Wadsworth				1.10	1 00	10
<i>New Jersey.</i>						
Belvidere	13.29	5.48	6	5.48	3 00	6
Blairstown	10.25					
Chester		2.65	6-7			
Junction	10.64	3.93	6			
Newark	10.28	4.55	5-6			
Oceanic		2.91	5-6			
Somerville		3.05	5-6			
<i>New York.</i>						
Appleton		2.56	20			
Buffalo		3.56	19-20			
Fort Niagara		2.05	20			
Honeyhead Brook		3.09	3-4			
Lockport		4.24	20			
New York				1.04	0 55	6
Number Four		2.86	20-21			
Oswego		3.30	19-20			
Palermo		2.85	20			
Port Jervis		3.18	9			
<i>North Carolina.</i>						
Asheville		2.55	8-9			

TABLE XIII.—Excessive precipitation.—Continued.

Stations.	Monthly rainfall 10 inches, or more.	Rainfall 2.50 inches, or more, in 24 hours.		Rainfall of 1 inch, or more, in one hour.		
		Amt.	Day.	Amt.	Time.	Day.
North Carolina—Continued.		Inches.	Inches.	Ina.	A.m.	
Beaufort.....		2.73	17			
Biltmore.....		3.10	8			
Bryson City...	10.30					
Chapelhill.....		3.89	7			
Fairbluff.....		2.80	7			
Flatrock.....	13.77	5.23	8			
Greensboro.....		2.64	8			
Hatteras.....				1.23	0 59	25
Henderson.....		2.88	8			
Horse Cove.....	11.58	5.10	7-8			
Jacksonville.....	13.67	4.65	16-17			
Jefferson.....		3.57	8			
Kittyhawk.....		2.50	16-17	2.00	1 30	16
Lenoir.....		8.78	7-8			
Linnville.....	11.74	4.00	8			
Lynn.....		2.71	7			
Mocksville.....		3.29	7-8			
Moncure.....		2.60	7-8			
Monroe.....		4.54	7-8			
Mountairy.....				2.27	1.00	27
Mount Pleasant.....		3.00	7			
Newbern.....	11.61					
Oakridge.....		3.47	8-9			
Pittsboro.....		4.30	7-8			
Rockingham.....		4.68	7-8			
Roxboro.....	12.56	4.62	8			
Salem.....		2.69	8			
Saxon.....	10.44	5.24	7-8			
Settle.....	11.08	4.25	7-8			
Skyuka.....	11.04	5.41	8			
Soapstone Mount.....	10.19	5.12	7-8			
Southern Pines.....		3.20	8			
Waynesville.....	12.05	3.46	7-8			
Wilkesboro.....		5.00	8			
North Dakota.						
Wahpeton.....		3.05	25			
Ohio.						
Bangorville.....		2.76	15	1.01	0 40	5
Basil.....		3.30	22-23			
Bellfontaine.....		2.55	27			
Benton Ridge.....		2.50	15			
Bigprairie.....		3.00	15			
Cambridge.....	12.72					
Camp Dennison.....				1.15	0 45	5
Canal Dover.....	10.07					
Cherry Fork.....		3.85	20-21			
Cincinnati.....				1.23	1 00	20
Clifton.....		4.12	23-24			
Colebrook.....				1.28	1 00	14
Columbus.....		3.01	23-24	2.00	1 00	24
Demos.....	16.13	4.25	6			
Dupont.....				1.00	0 40	2
Findlay.....	11.10					
Fostoria.....		2.71	14-15			
Granville.....		2.50	16			
Gratiot.....	11.69	2.92	23-24			
Greenville.....		3.02	23-24			
Hackney.....	10.27					
Lancaster.....	10.12	2.75	24-25			
McArthur.....		3.32	14	3.32	1 00	14
McConnellsville.....		2.67	24			
Milligan.....		2.75	24			
Montpelier.....	10.62					
Neapolis.....	11.43	4.60	19-20			
New Alexandria.....	11.28					
New Moscow.....	10.94	2.90	24			
North Lewisburg.....	14.15	2.89	24			
Pataskala.....	11.83	2.89	24	1.07	0 25	27
Philo.....		2.89	24			
Plattsburg.....	10.30	4.32	24	4.20	4 05	24
Pomeroy.....		3.49	20-21			
Portsmouth.....		3.27	20-21			
Ridgeville Corners.....	10.75	4.49	19-20			
Sharon Center.....				1.28	0 20	4
Thurman.....		3.00	21			
Urbana.....	10.10					
Vanwert.....	10.18			1.22	0 55	27
Walnut.....		3.11	29			
Wauseon.....	11.01	3.00	14-15			
Oklahoma.						
Ponca.....		2.80	19-20			
Prudence.....		2.88	16	2.88	2 30	16
Stillwater.....				1.74	1 00	18
Winnview.....				1.82	1 00	4
Pennsylvania.						
Brookville.....	10.91					
Browsers Lock.....		2.83	22			
Cannonsburg.....	11.07	2.80	27			
Do.....		2.70	30	2.70	2 30	30
Cedarrun.....				1.59	0 40	29
Center Hall.....				1.12	0 45	29
Confluence.....	12.11					
East Mauch Chunk.....				1.56	1 10	27
Easton.....	10.28	2.55	8-9			
Erie.....				2.22	1 02	4
Girardville.....	11.30	3.00	9			
Gramplan.....		2.76	15-16			
Greensboro.....	12.72					
Kennett Square.....				1.43	0 30	9
Lansdale.....		2.62	22			

TABLE XIII.—Excessive precipitation.—Continued.

Stations.	Monthly rainfall 10 inches, or more.	Rainfall 2.50 inches, or more, in 24 hours.		Rainfall of 1 inch, or more, in one hour.		
		Amt.	Day.	Amt.	Time.	Day.
<i>Pennsylvania—Continued.</i>						
Lock No. 4.....	12.35	3.05	27			
Lyolippus.....	12.04					
Ottsville.....		2.90	23			
Pittsburg.....			22	1.45	1 00	15
Seisholtzville.....	10.86	3.00				
Somerset.....	10.35					
Uniontown.....	15.59	3.92	27			
West Newton.....	11.46	2.71	27			
<i>South Carolina.</i>						
Batesburg.....		2.80	7-8			
Camden.....		4.25	8			
Charleston.....	10.58	2.60	2			
Do.....		2.91	9			
Cheraw.....				1.30	1 00	8
Clemson College.....	11.28	4.01				
Columbia.....	10.89	6.65	6-8			
Georgetown.....	10.47	2.77	11			
Greenville.....		3.33	10-11			
Greenwood.....	15.72	12.01	6-8			
Holland.....		3.90	7-8			
Kingstree.....	10.63	2.60	8			
Do.....		2.57	10			
Little Mountain.....	11.38	8.09	6-7			
Longshore.....	10.14	5.28	6-7			
Mount Carmel.....	10.37	7.79	6-8			
Port Royal.....				1.25	1 00	26
Saint Matthews.....	11.01	2.58	17			
Shaws Fork.....		4.00	6-7			
Spartanburg.....		2.55	7-8			
Statesburg.....	11.15	4.97	6-7			
Trenton.....		6.16	6-8			
Winnaboro.....		3.32	7			
Yemassee.....				1.11	0 40	25
<i>South Dakota.</i>						
Forest City.....		2.50	8			
Highmore.....		4.72	8	4.72	2 00	8
Rosebud.....				1.65	1 00	18
St. Lawrence.....		4.00	29-30			
Shiloh.....		3.64	3			
<i>Tennessee.</i>						
Brownsville.....				1.00	0 45	12
Chattanooga.....				1.13	0 48	7
Clinton.....	15.72	3.30	6-7			
Elizabethton.....	10.56					
Elk Valley.....	10.68			2.12	2 00	24
Greeneville.....	11.85	3.24	8			
Jackson.....		5.06	4-5	4.00	0 40	4
Johnsonville.....		2.51	21-22			
Jonesboro.....		2.78	7-8			
Liberty.....	10.07			1.75	1 00	21
Nashville.....				1.30	1 00	2
Do.....				1.37	1 00	12
Nunnally.....				1.56	1 30	22
Palmetto.....				1.25	1 00	3
Riddleton.....		2.68	21-22			
Rockwood.....	11.82	2.80	21-22			
Rugby.....	11.32					
Springdale.....	14.82	3.30	5-6	3.00	1 45	8
Do.....				1.60	1 00	12
Do.....		3.10	15-16	1.00	1 00	27
Tullahoma.....	10.40					
<i>Texas.</i>						
Beeville.....		2.75	11-12	1.50	1 30	8
Blanco.....		3.00	12			
Boerne.....		4.32	11			
Brazoria.....		5.13	11			
Columbia.....		4.01	11-12			
Danewang.....		6.25	11			
Dean.....		2.72	30			
Forestburg.....				1.40	1 15	14
Galveston.....				1.23	1 00	11
Hale Center.....		4.80	17			
Haskell.....				1.15	1 00	10
Henrietta.....				1.58	1 30	11
Luling.....				1.53	1 00	6
Mount Blanco.....		3.00	18			
Stafford.....		4.30	10-11	2.40	1 00	10
Victoria.....		4.38	12			
<i>Utah.</i>						
Snowville.....				1.03	1 00	6
<i>Virginia.</i>						
Blacksburg.....		3.12	8			
Callaville.....	10.23	2.53	6	2.30	2 00	6
Do.....		5.59	7-8			
Clarksville.....		3.06	6-7			
Grahams Forge.....		5.01	8			
Lexington.....		2.95	8-9			
Lynchburg.....		4.80	7-8	1.64	1 00	8
Norfolk.....				1.03	1 00	10
Petersburg.....		3.37	6-7			
Rockymount.....		4.25	8			
Spottsville.....	11.23	3.50	7-8			
Standardsville.....		3.79	6	3.00	1 15	6
Sunbeam.....	10.21			1.54	1 15	21
<i>West Virginia.</i>						
Beverly.....	15.60	2.80	21-22			
Do.....		4.15	24			
Buckhannon.....	13.63					
Burlington.....			2.30	1 00	24	
Dayton.....	14.10					

TABLE XIII.—Excessive Precipitation.—Continued.

Stations.	Monthly rainfall 10 inches, or more.	Rainfall 2.50 inches, or more, in 24 hours.		Rainfall of 1 inch. or more, in one hour.		
		Amt.	Day.	Amt.	Time.	Day.
West Virginia.—Continued.						
Fairmont	18.33	4.20	24			
Glenville	14.15	3.15	14			
Grafton	11.19					
Hewett				1.00	1 30	30
Martinsburg		2.65	23-24			
Morgantown a	13.98	2.78	22			
Do.		5.49	24			
New Martinsville	15.06	3.77	24			
Parkersburg	11.46	2.70	21-22			
Pennsboro	13.54	5.87	21-23			
Philippi	15.70	2.80	24	1.30	1 00	12
Do		2.80	30	2.80	2 00	30
Rowlesburg	12.14					
Weston s.	15.15	2.86	22			
Wheeling s.	11.08					

TABLE XIII.—Excessive Precipitation.—Continued.

Stations.	Monthly rainfall 10 inches, or more.	Rainfall 2.50 inches, or more, in 24 hours.		Rainfall of 1 inch, or more, in one hour.		
		Amt.	Day.	Amt.	Time.	Day.
<i>Wisconsin.</i>		<i>Inches.</i>	<i>Inches.</i>	<i>Ins.</i>	<i>A.m.</i>	
Appollonia.....		1.88	1 00	3
Beloit.....		3.50	26	.....	.....
Delavan.....		5.07	26	.....	.....
Hartford.....		1.03	0 45	2
Medford.....		3.05	12	.....	.....
New Holstein.....		2.71	26	.....	.....
Racine.....		2.97	26-27	.....	.....
Sharon.....		4.45	26	4.25	3 00
Shawano.....		2.95	3-4	.....	.....
Valley Junction.....		2.95	14	.....	.....
<i>Wyoming.</i>						
Cheyenne.....		4.70	15	4.70	3 05

*Partly estimated.

Chart I. Tracks of Centers of Low Areas. July, 1896.

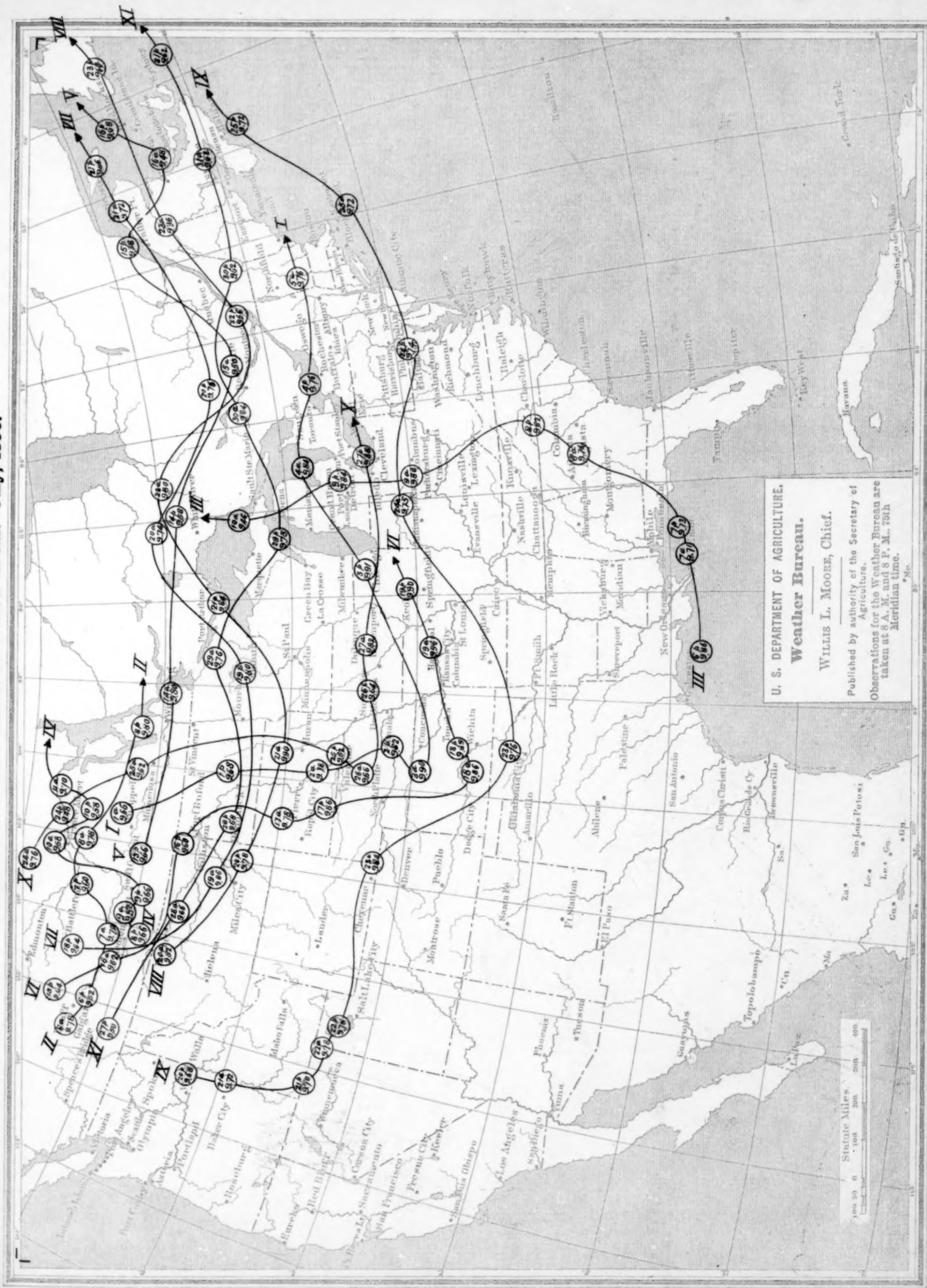


Chart II. Tracks of Centers of High Areas. July, 1896.

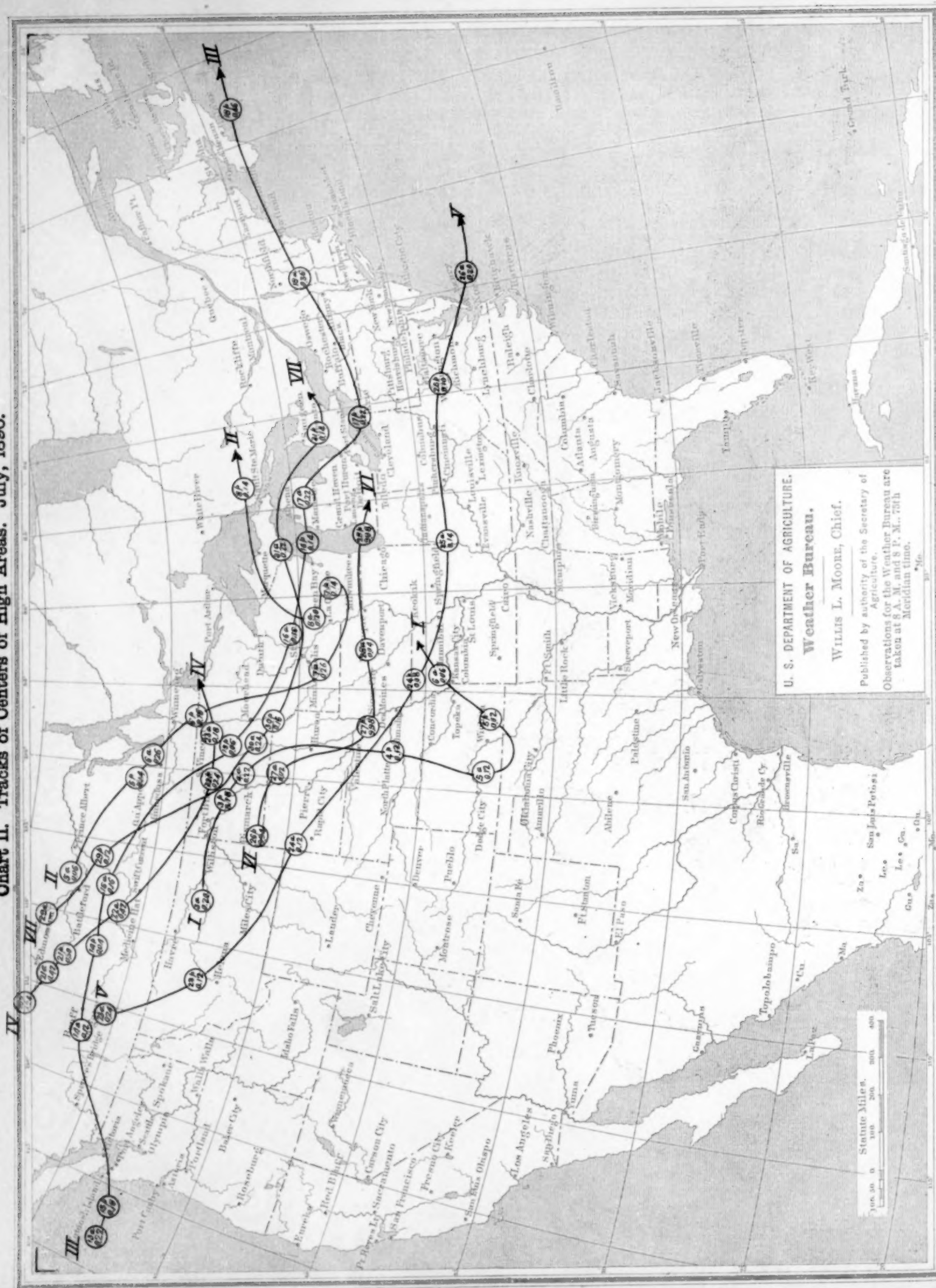


Chart III. Total Precipitation. July, 1896.

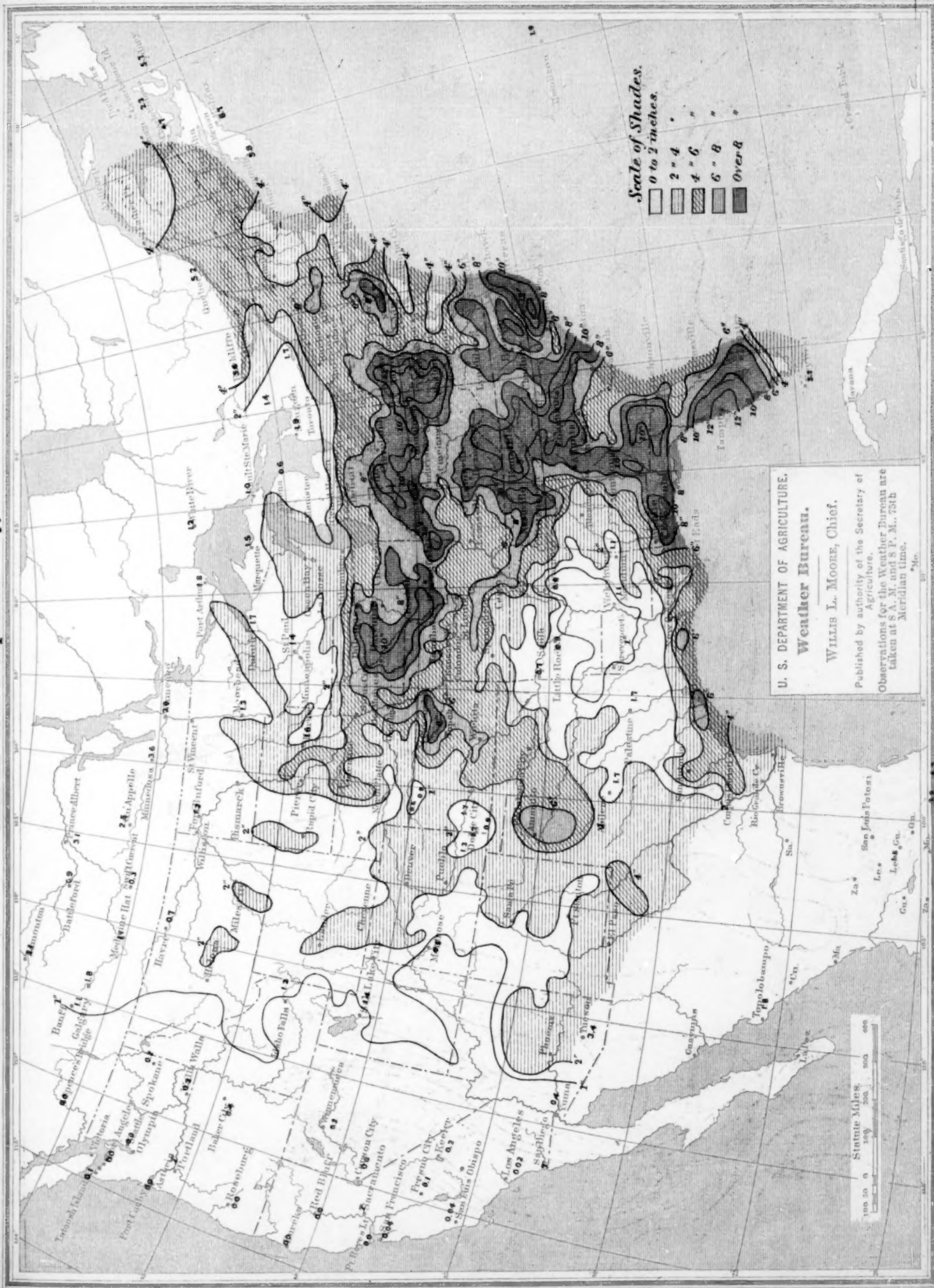
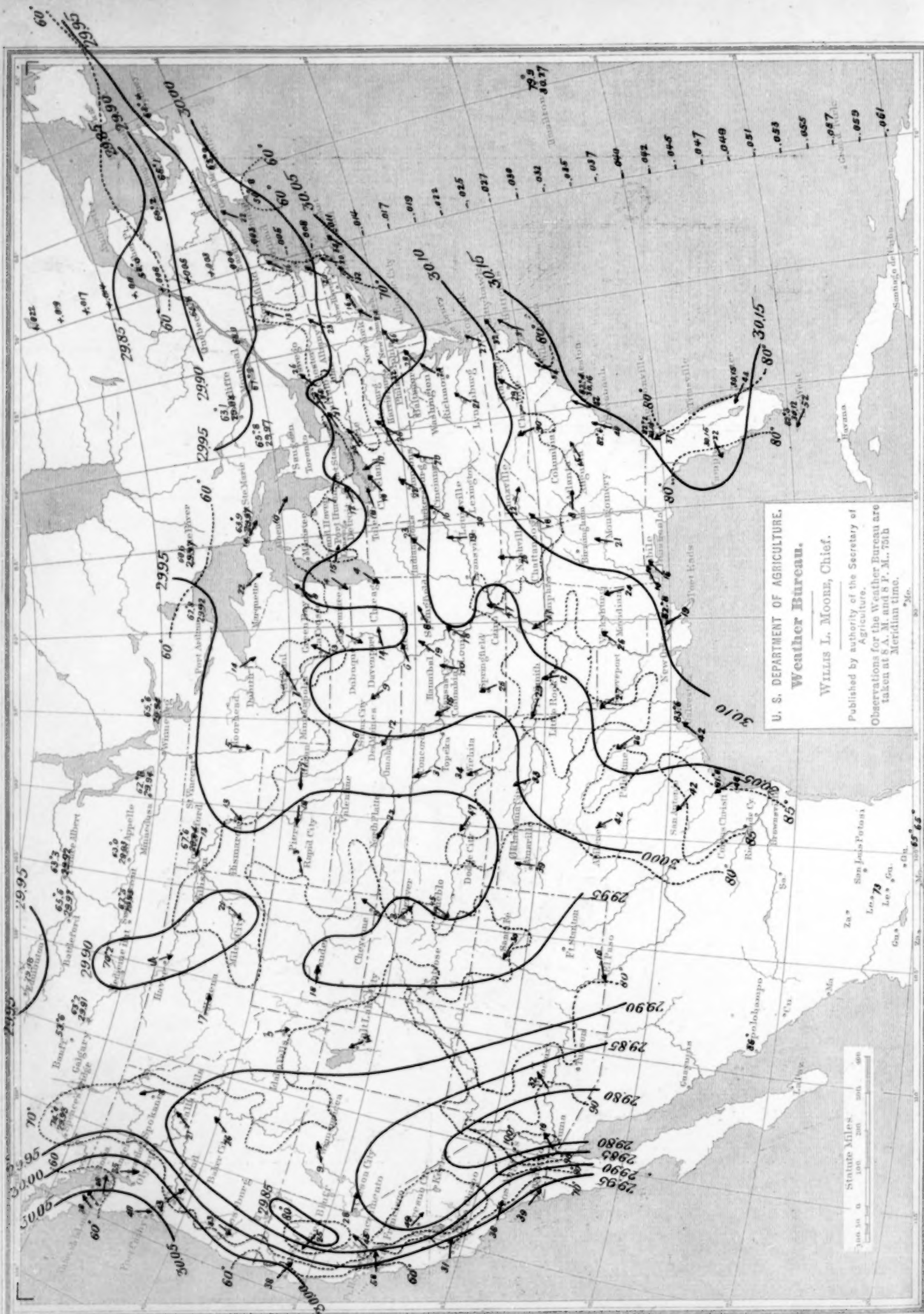


Chart IV. Isobars, Isotherms, and Resultant Winds. July, 1896.



U. S. DEPARTMENT OF AGRICULTURE.

Weather Bureau.

WILLIS L. MOORE, Chief.

Published by authority of the Secretary of Agriculture.

Observations for the Weather Bureau are taken at 8 A. M. and 8 P. M. 75th Meridian time.

Statute Miles.
0 100 200 300 400

Chart V. Kite Experiments at the Weather Bureau.

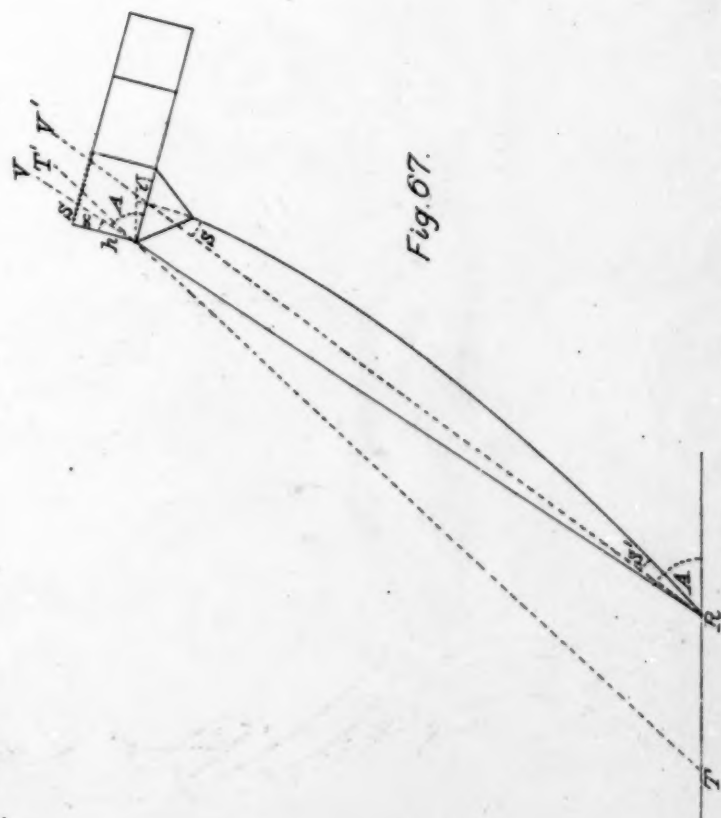
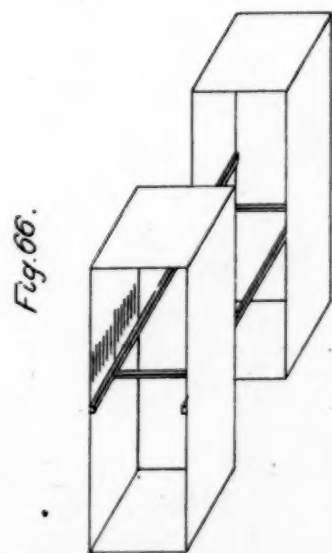
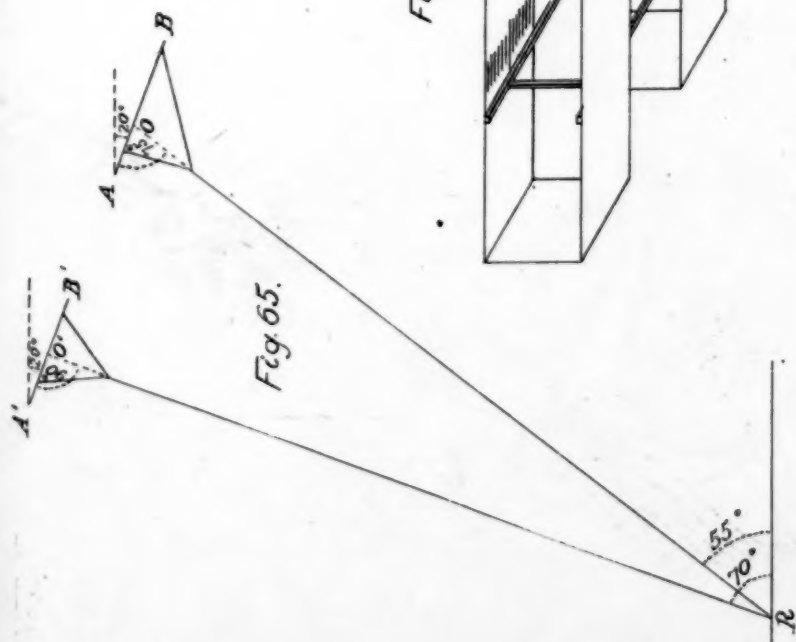


Fig. 68.

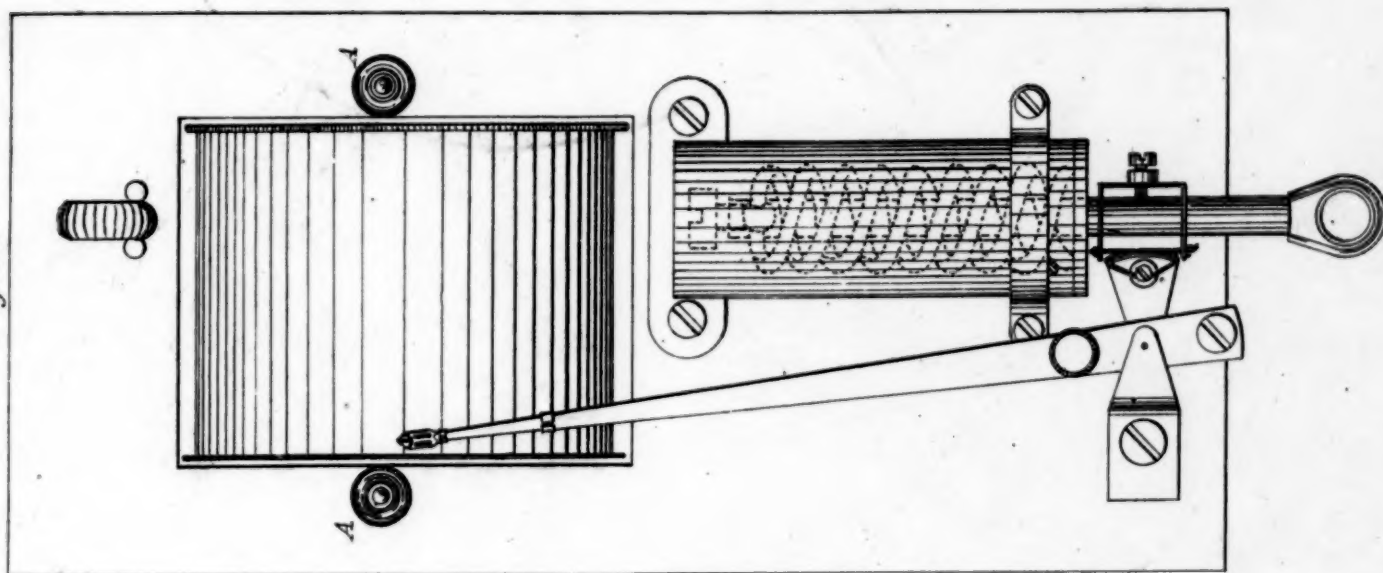


Chart VI. Kite Experiments at the Weather Bureau.

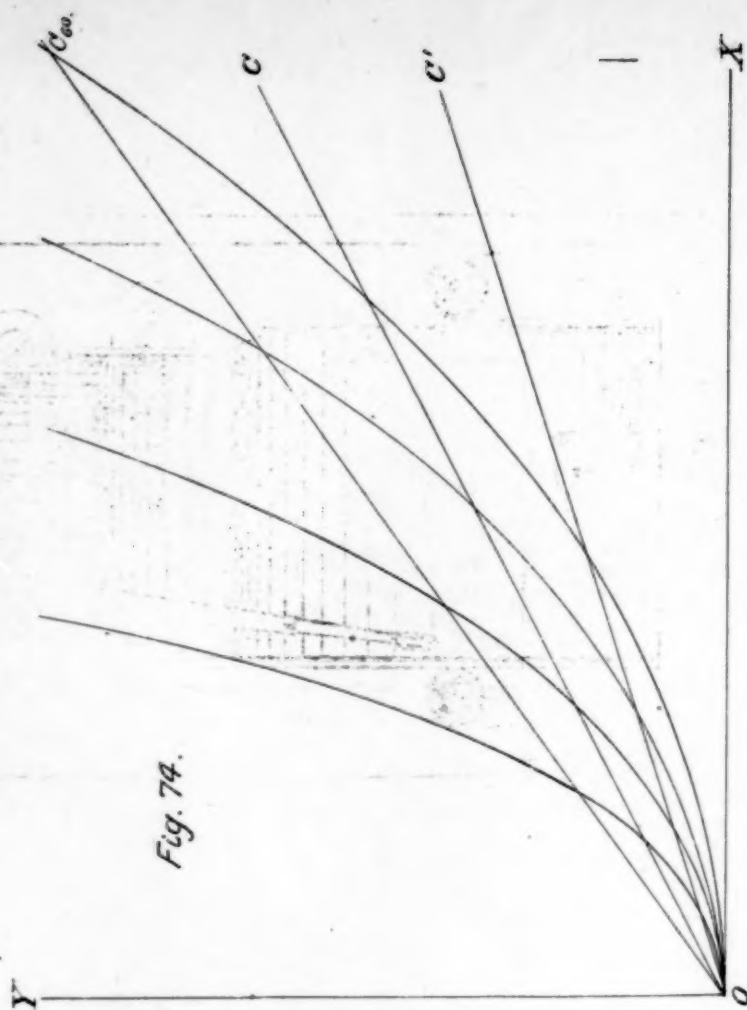
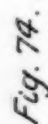
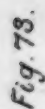
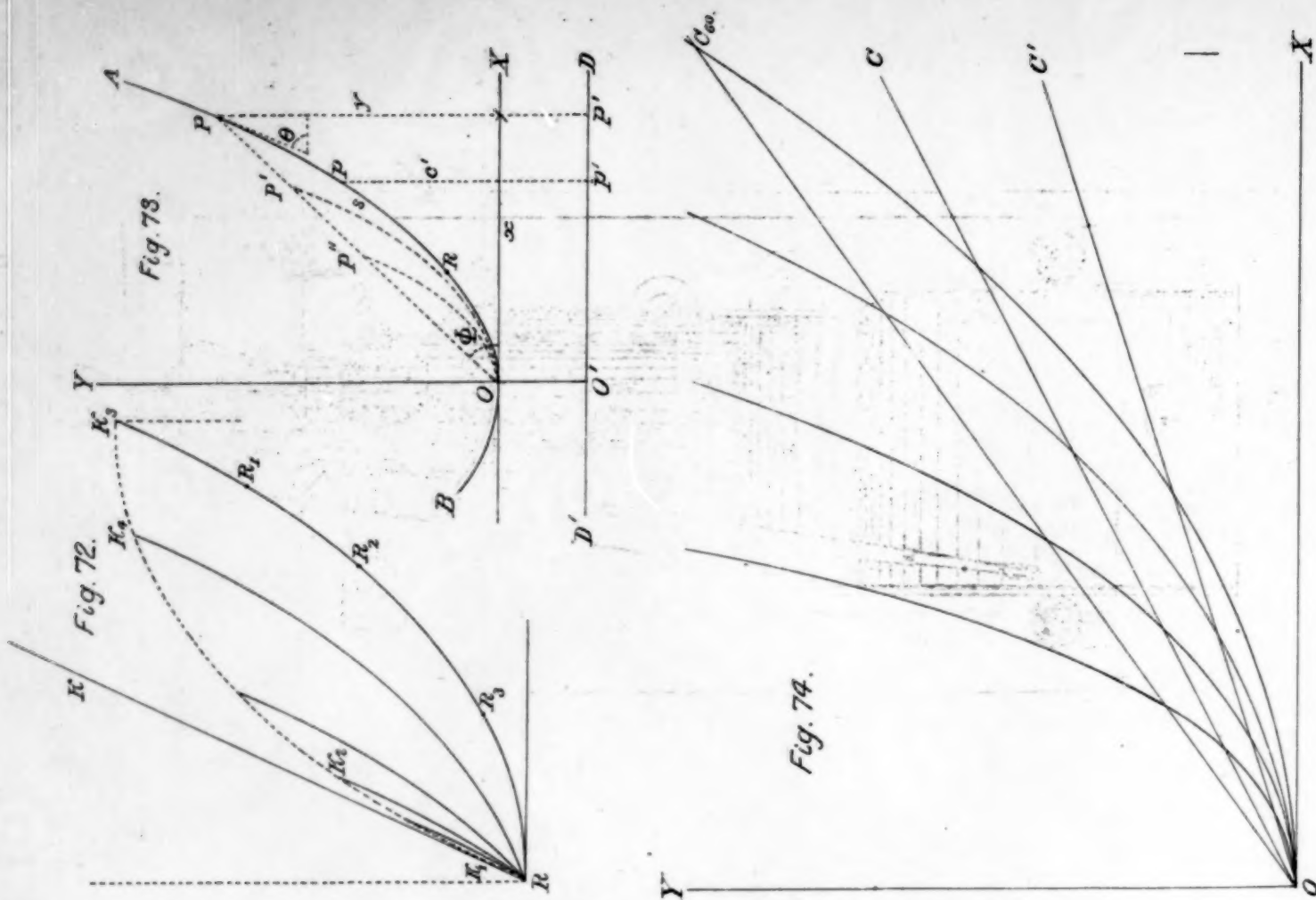
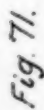
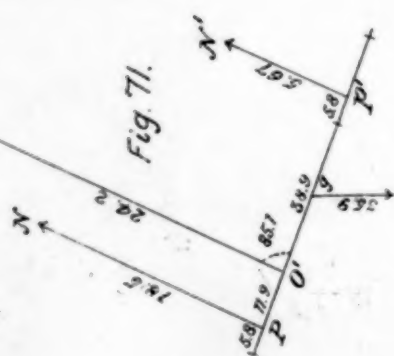
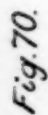
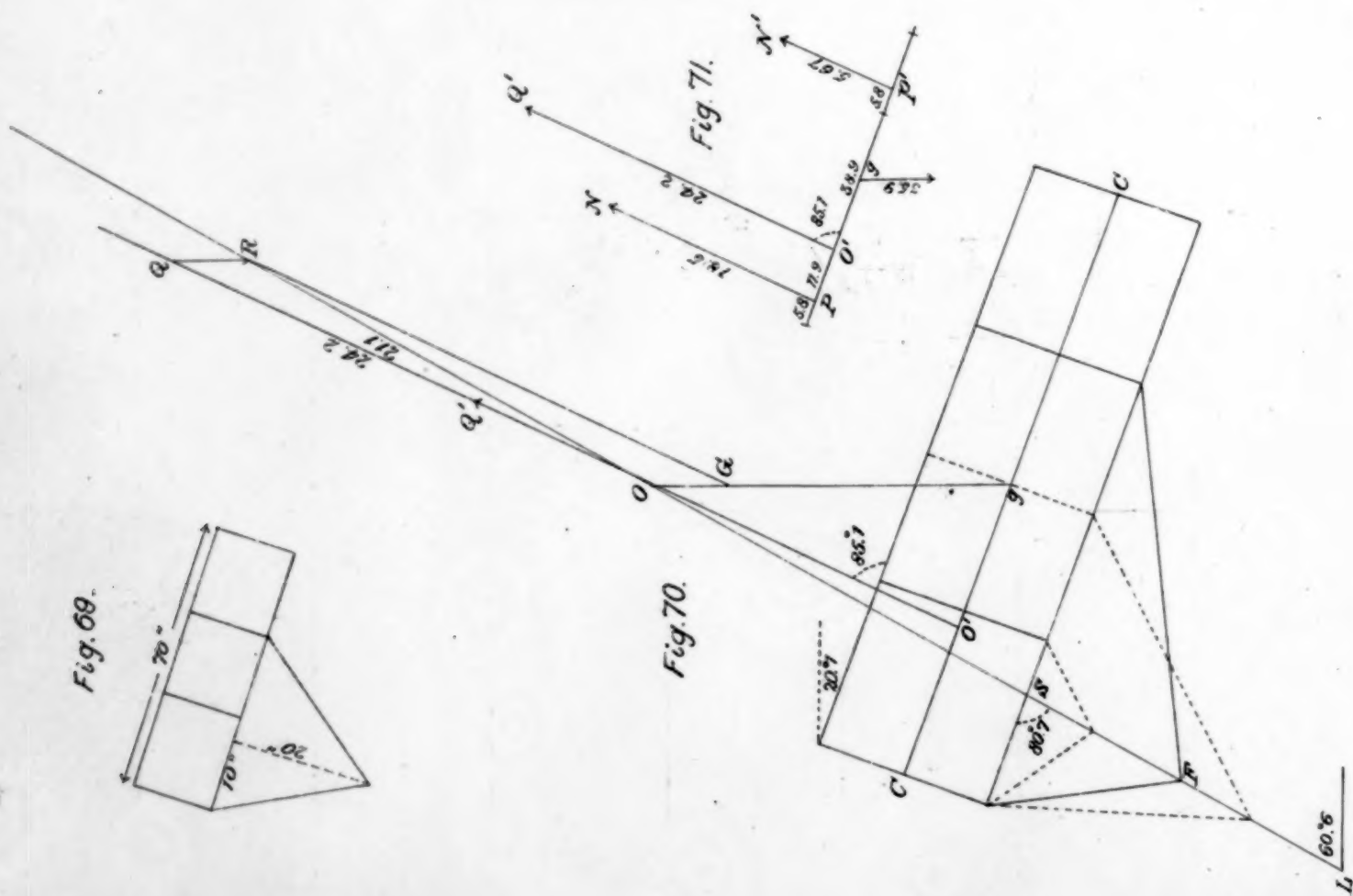
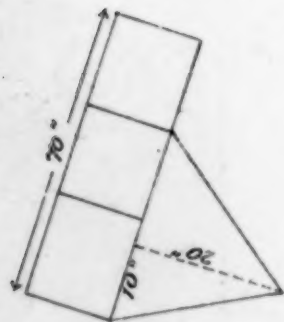
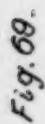
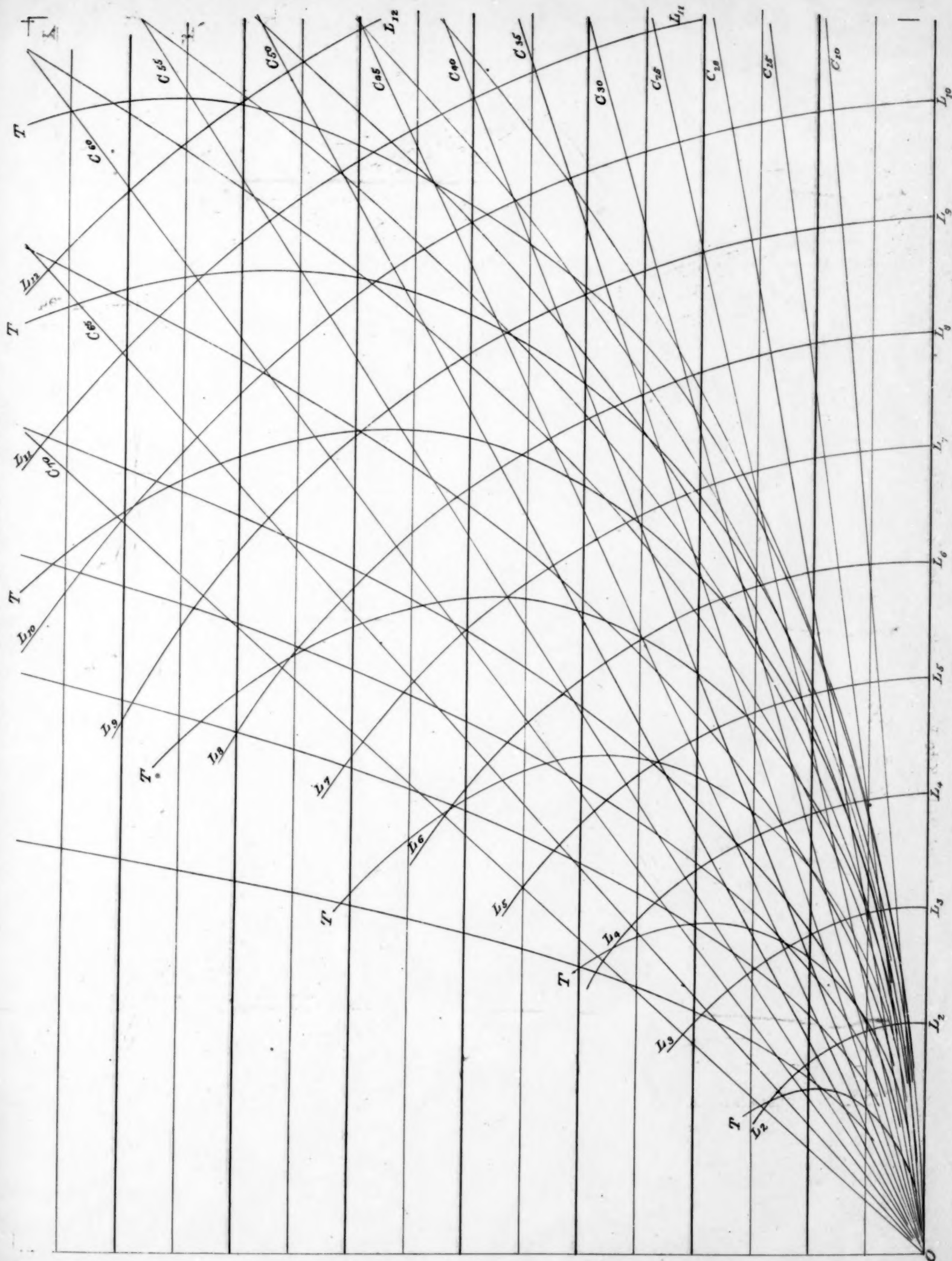


Chart VII. Kite Experiments at the Weather Bureau.



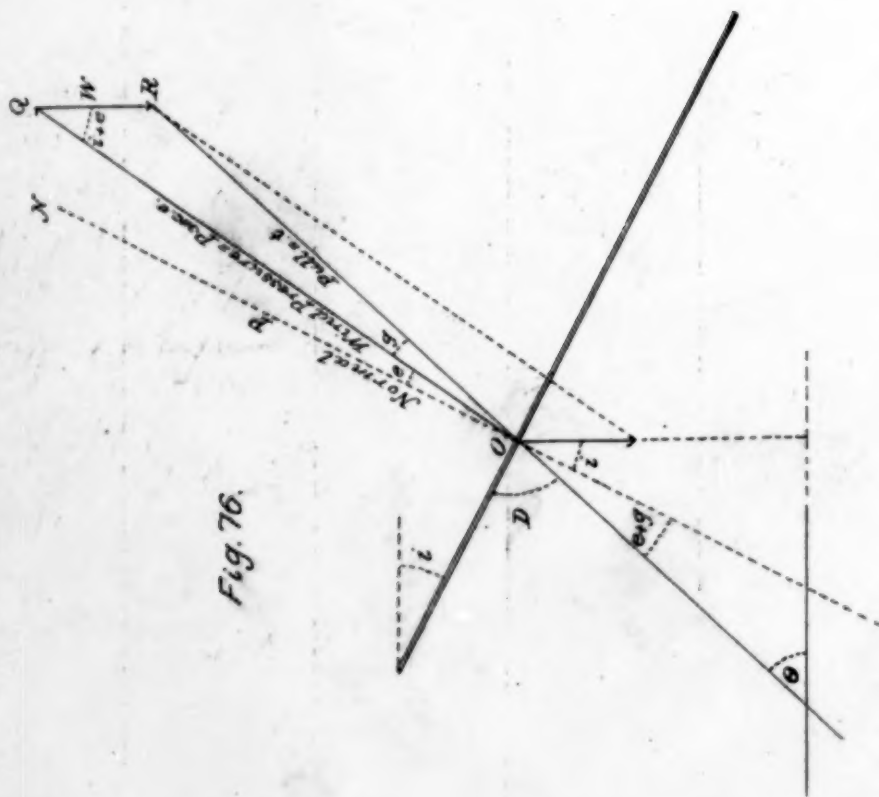


Fig. 76.

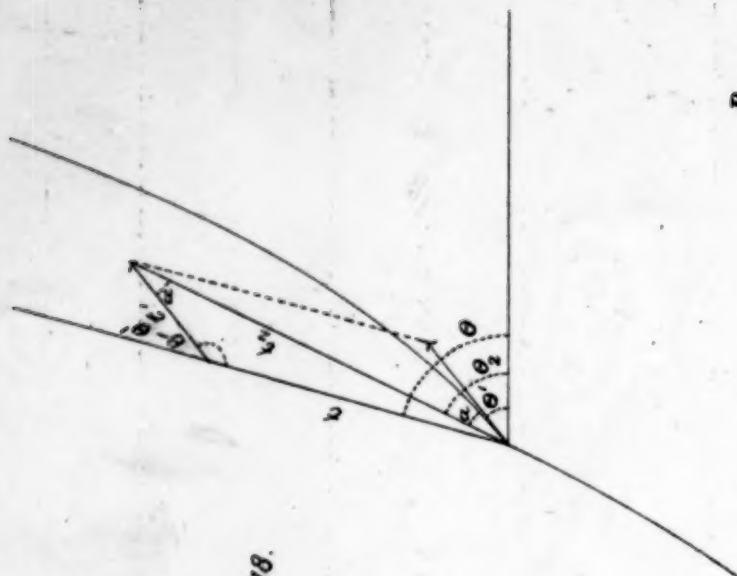


Fig. 78.

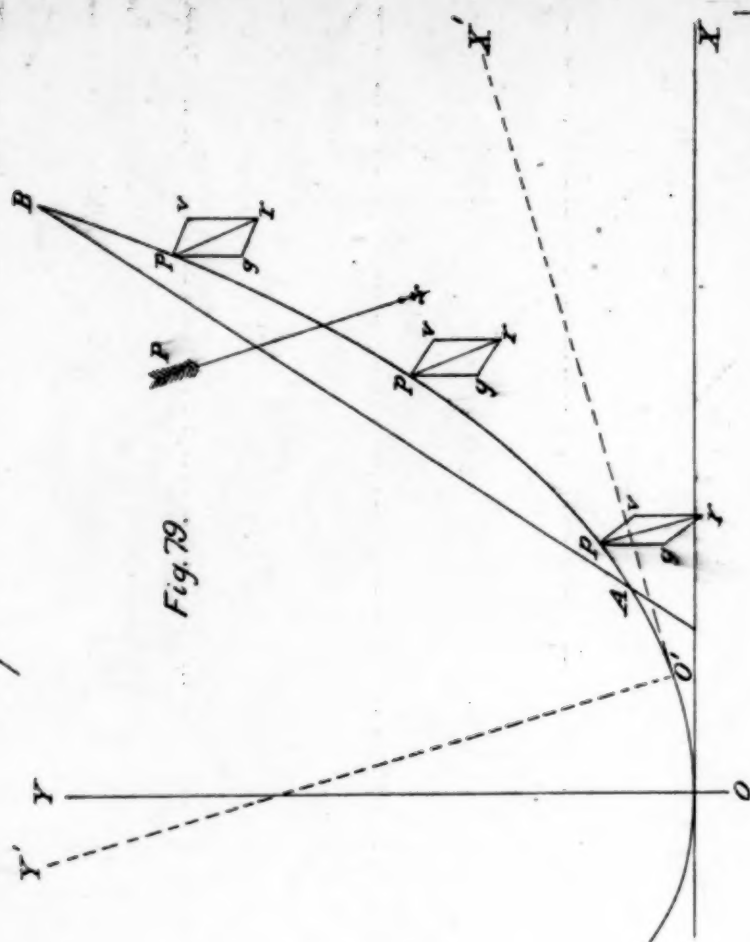


Fig. 79.

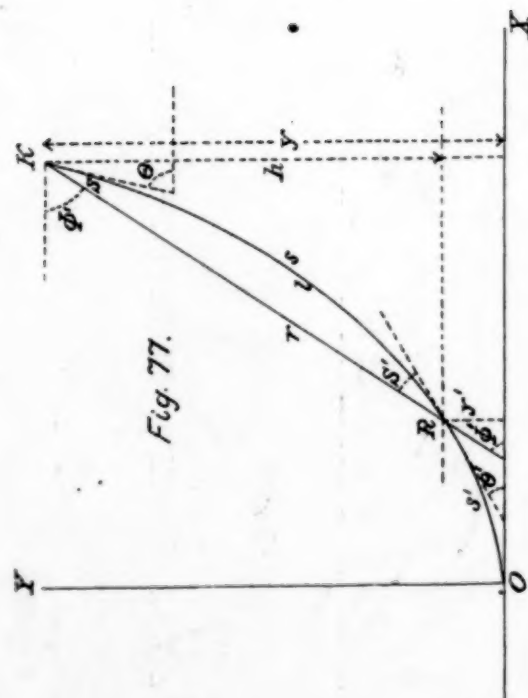


Fig. 77.